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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY

OF GLASGOW.

VOL. VIII.

1884-1888.

GLASGOW: PUBLISHED BY THE SOCIETY,
AT ITS ROOMS, 207 BATH STREET.

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The Editor begs to state that the Authors are alone responsible for the facts and opinions contained in their respective papers.

JAMES BARCLAY MURDOCH, F.R.Ph.S.E.

ROBERT MACLEHOSE, PRINTER, 153 WEST NILE STREET.

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Page 76, 1st line, *read* Blarmacfoldach.

Page 79, 4th line from bottom, *for* Dungardil, *read* Dunjardil.

Page 97, 5th line from bottom, *for* so, *read* no.

Page 99, middle title, *for* Gollarig, *read* Collarig.

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

No. I.—Notes on Cone-in-Cone Structure. By John Young, F.G.S., *V.P.* With Illustrations. [Plates I. and II.]

[Read 12*th March*, 1885.]

Having for a considerable number of years collected all the varieties of the remarkable structure known as Cone-in-cone which have come under my observation on the excursions of this Society to different localities within the bounds of our Western Scottish coalfield, and having recently obtained many beautiful and interesting examples from a locality first brought under notice by Mr. Robert Craig, corresponding member, Langside, Beith, I intend, in the following notes, to offer some remarks on these and other Scottish specimens, as presenting points of structure, and other external and internal characters, which, in the descriptions that I have met with, do not seem to have been noticed, or if observed have not been properly understood, but which, I think, when rightly interpreted, will lead to more correct explanations of this structure than any that have been advanced.

Before describing these specimens, however, I shall here shortly refer to the several descriptions which I have been able to obtain from those authors who have formerly noticed Cone-in-cone structure, and for some of these references I am indebted to our Honorary Associate, Prof. J. W. Judd, London, whom I here thank for the trouble he has kindly taken for me in this matter.

The first notice I find is one by the Rev. David Ure, M.A., in his "History of Rutherglen and East Kilbride, 1793," where he states, p. 253, "The most uncommon variety of till in this

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country is one that, by the miners, is called *Maggy*. It is incumbent on a coarse ironstone, or doggar, at Mauchlanhole and Torrance, and is generally found in the shape of cones, as pl. xx., fig. 8. These cones are of a dirty black colour, and are composed of concentric lamellæ of various thickness, and which may be separated from one another, exhibiting surfaces adorned with small but irregular undulations. The apices of the cones, which are of various dimensions, rest upon the stone, and the bases are lost in the surrounding till. They are softest at the base, but gradually increase in hardness towards the apex. The whole, however, is in general very hard. This curious fossil contains, along with clay, a considerable proportion of iron and lime, and perhaps some other substance which co-operates in the formation of its peculiar figure." In the plate to which Ure refers, the specimen has been drawn upside down, as the apices of the cones should be downwards, as he correctly describes them, but not upwards as shown in the figure. There is no mistaking in the clear description given that he is referring to Cone-in-cone structure.

The second notice is contained in the Report of the British Association for 1859, where there is a note, p. 124, "On the origin of Cone-in-cone," by H. C. Sorby, F.R.S. He says that "Cone-in-cone is met with in so many stratified rocks that most geologists must be familiar with its general characters, though no one appears to have thoroughly investigated it or to have given any very satisfactory explanation of its origin. The cones often occur in bands parallel to the stratification of the rock, their apices starting from a well-defined plane, and after extending upwards or downwards for a greater or less distance, with their axes perpendicular to the plane of the stratification, they end in bases parallel to it, but not all at the same exact level, some standing up above the general surface. They are not perfect cones, but are of such forms as would result from the varied interference of surrounding cones, and from the development of others within their own substance. On examining their transparent sections with a low magnifying power under polarized light, the author had been able to ascertain that this peculiar structure is intimately connected with some kind of oolitic grains. In the formation of the most abundant variety of oolitic grains small prismatic crystals of more or less pure carbonate of lime were deposited around a

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nucleus in nearly the same amount on all sides so as to give rise to irregular ovoid bodies, whereas in the formation of Cone-in-cone very similar crystals were deposited almost entirely on one side, along the axis of the cones, in such a fan-shaped manner as to give rise to their conical shape. In the thin sections of some specimens every connecting link between imperfect oolitic grains and genuine cones can be seen to great advantage with polarized light. The growth of the cones did not, however, proceed without interruption, for other smaller fan-shaped groups were developed within the larger; and thus by the mutual interference of contiguous groups and of others contained within themselves there was formed a mass of irregular cones enclosing other cones." "The author concludes that this structure is one of the peculiar forms of concretions, formed after the deposition of the rock in which they occur, by the crystallization of the carbonate of lime and other isomorphous bases."

The third notice is that quoted by Prof. A. Geikie in his "Text-Book of Geology, 1882," where he states, p. 313, that "Prof. Marsh suggests that the complex structure known as 'Cone-in-cone' may be due to the action of pressure upon concretions in the course of formation." (*Proc. American Assoc. of Science*, 1867.)

The fourth notice is contained in an appendix to Dr. Dawson's "Acadian Geology, 1868," in which there is a note, pp. 676-77, on what are termed "Cone-in-cone concretions." In writing of these, Dr. Dawson says, "In these nodular layers also, as well as in certain layers of hard argillaceous matter, we often find the remarkable structure to which this note relates. It consists of a series of conical forms often running together into rows and ridges, and consisting of a series of concentric coats, whence the name 'Cone-in-cone,' given by the miners. The surfaces of the coats are also curiously marked with transverse ridges giving a wrinkled appearance, so much resembling some organic structures as to deceive some persons into the belief that these curious forms may be fossils." Dr. Dawson further refers to specimens sent him, one of which he figures, but like that given by Ure, to which I referred above, the figure is also drawn upside down. In exhibiting these specimens to the Natural History Society of Montreal, he states his belief that they are produced by "concretionary action proceeding from the surface of a bed or layer, and modified by the gradual compression of the material."

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The fifth notice is to be found in the "Students' Manual of Geology," by Professor J. Beete Jukes, third edition, edited by Professor A. Geikie, 1872. At p. 312 it is stated that "some clay ironstones exhibit another concretionary form called 'Cone-in-cone,' as the seam of ironstone breaks into conical forms with the bases of the cones at top and bottom of the seam, and their apices pointing inwards towards each other. The surfaces of these cones are corrugated by small horizontal fretted wavelets, or ridges, rather resembling those on the outside of some stalactites, and each cone is concentrically enveloped by several coats, the surface of each being similarly corrugated. Some coals also exhibit a curious structure in the interior, somewhat analogous to this, showing, when parted, a series of narrow winding corrugated ridges and furrows, about an inch wide and deep, fitting closely into each other till separated with some little force."

The sixth notice is by R. Daintree, F.G.S., in a paper on the Geology of Queensland, *Quarterly Journal Geol. Soc.*, vol. xxviii., 1872, where he makes a short reference to "Cone-in-cone," and gives an analysis. At page 282 he says, "One other peculiarity in the strata forming the series is the presence at intervals of thin layers of limestone having the well-known Cone-in-cone structure. This has more the appearance of a chemical precipitate than a mechanical deposit, and contains no fossils." Its analysis gave—

Insoluble in hydrochloric acid, ...	14·920
Ammonia precipitate, ...	4·860
Carbonate of lime, ...	75·458
Undetermined constituents, ...	4·762
	100·000

The seventh and last notice which I have obtained is to be found in the *Quarterly Journal Geol. Soc.*, vol. xxix., 1873. At p. 418 there is a short discussion on some peculiar striated markings in chalk, which were thought by some to be of organic origin. "A note was read by Mr. Whitaker from Mr. Judd, who held that these specimens were not due to any organic origin, and that the structures known as 'Cone-in-cone,' or 'beef,' which he terms 'quasi-crystalline structures,' seemed to him to be closely related."

From these quotations it will be seen that the descriptions of Cone-in-cone structure are somewhat varied and conflicting—one

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author ascribing it to concretionary action, the result of a kind of quasi-crystallization; another to the action of pressure on concretions in the course of formation; and a third to chemical precipitation. None of them, however, notice all the characters to be seen in Cone-in-cone, at least as revealed in the best-preserved Scottish specimens; and I think, after careful examination, that these clearly indicate other agencies at work in the formation of the structure, the actions of which were totally different in character and in time from those heretofore noticed.

The specimens of Cone-in-cone which seem to throw new light on the origin of the structure were obtained from an old open-cast quarry at Waterland, near Lugton station, Dunlop, Ayrshire, and, as formerly stated, were first brought under the notice of the Society by Mr. R. Craig. In this quarry the main seam of clay-band ironstone of North Ayrshire is brought to the surface through the action of a fault. In other localities in Ayrshire, as well as in Renfrewshire and North-west Lanarkshire, this ironstone has been, during recent years, extensively mined in numerous pits throughout these districts. Its geological position is in the group of lacustrine strata that here separates the upper from the lower division of the Carboniferous limestone series of Western Scotland. The Cone-in-cone stratum in the Waterland Quarry is seen to rest directly on the clay-band ironstone, and forms a thin band seldom exceeding four inches in thickness, the average being from one to two inches. It is overlaid by a bed of soft, black, carbonaceous shale, and this again by strata of flaggy sandstone. The Cone-in-cone stratum on this horizon has been found extending, but somewhat irregularly, along with the ironstone, over nearly the whole tract of country in which the ironstone has been worked, and this embraces places more than twelve miles apart; but the two localities that have yielded the best preserved examples are the quarry at Waterland and one of the pits near Paisley. The Cone-in-cone stratum parts readily from the ironstone, as well as from the overlying shale, and in the quarry at Waterland is found in small slabs, lying on the shale heap, where it has been cast aside during the working of the ironstone. Through the action of the weather, both the upper and lower surfaces of these slabs have been cleaned of the most of the adherent shale, and they reveal the interesting fact that in this instance the Cone-in-cone stratum has been originally a thin bed of stratified shale, composed in great bulk of the calcareous

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shells of Entomostraca, of the genera *Carbonia*, *Leperditia*, and *Beyrichia*, of species frequenting lacustrine waters. This is confirmed by the circumstance that in a pit near Lugton station, about a quarter of a mile distant from Waterland Quarry, as well as in pits near Dalry in which Cone-in-cone structure in this stratum is absent, or only very feebly developed, the shale exists as a finely-stratified deposit, every layer being crowded with Entomostracan shells. Where the Cone-in-cone structure has been best developed, the Entomostraca are almost entirely obliterated, not a trace of them being seen, except in some few specimens, where they occur on both the lower and upper faces, but not in the central portion of the bed. Along with these organic remains, the stratum also contains a few scattered coprolites, and scales and teeth of small ganoid fishes. Coprolites are also found in the clay-band ironstone, but both in it and the overlying black shale the Entomostraca are almost entirely absent.

When newly fractured, the Cone-in-cone stratum is of a black colour; but under the influence of the atmosphere it weathers into a yellowish-grey rock. It is strongly calcareous, but does not contain much iron, and for this reason it is thrown aside in the workings as of no value. It contains a small amount of hydrocarbon, probably derived from the organisms once contained in the bed, and to which its dark colour is chiefly due. The more highly calcareous condition of the Cone-in-cone stratum, over that of the underlying clay ironstone and the overlying black shale, may be accounted for by the abundance of the Entomostraca originally contained in this bed. These organisms, in their decay, would naturally give off carbonic acid and other gases, and these would act upon the carbonate of lime of the shells, and in time would naturally dissolve it; the resulting calcareous matter combining with the clay of the deposit, and ultimately forming the material out of which the Cone-in-cone structure has been elaborated.

Mr. J. Holms Pollok, of the Chemical Laboratory, University, Glasgow, has kindly made for me the following analyses of specimens:—1st, Cone-in-cone from Waterland Quarry (No. 1 specimen). 2nd, two analyses of No. 1 specimen to find the difference in the amount of lime present between the bottom and the top layers of the cones—it having occurred to me, in accordance with the theory which I hold of this cone formation, and to which attention will be directed in a subsequent portion of this paper, that

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if the lime was partly due to the dissolving action of carbonic acid upon the shells and other organisms of the deposit, it ought to be more abundant in the calcareous sediment forming the upper portion of the cones than in the sediment at the base. This view, I am glad to say, is borne out by the analyses. 3rd (No. 2 specimen), Entomostracan shale from Lugton pit, near Waterland, in which the cone structure is not developed. 4th (No. 3 specimen), clay-band ironstone from Waterland Quarry, on which the cone stratum immediately rests, but downwards into which it does not extend.

Cone-in-cone (No. 1 specimen). Waterland Quarry.

Silica, etc.,	14·60
Organic matter,	?
Water,	1·83
Ferrous Oxide,	1·30
Ferric Oxide,	
Manganese,	Trace.
Alumina,	2·37
Lime,	39·95
Magnesia,	·90
Potash and Soda,	1·25
Carbonic Acid,	37.00
Sulphuric Acid,	·50
Phosphoric Acid,	
	99·70

Cone-in-cone (No. 1 specimen).

	Lime present.
Upper portion of stratum,	47·14
Lower portion of stratum,	38·60

Entomostracan Shale (No 2 specimen). Lugton Pit.

Silica, etc.,	48·58
Organic matter,	·76
Water,	6·40
Ferrous Oxide,	2·12
Ferric Oxide,	2·57
Manganese,	Trace.
Alumina,	3·19
Lime,	13·80
Magnesia,	1·00
Potash and Soda,	1·70
Carbonic Acid,	14·40
Sulphuric Acid,	2·08
Phosphoric Acid,	2·31
	98·91

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Clay-Band Ironstone (No. 3 specimen). Waterland Quarry.

Silica, etc., ...	13·41
Organic matter, ...	·85
Water, ...	2·47
Ferrous Oxide,...	36·90
Ferric Oxide, ...	2·20
Manganese, ...	Trace.
Alumina, ...	·60
Lime, ...	6·45
Magnesia, ...	2·70
Potash and Soda, ...	——
Carbonic Acid, ...	33·30
Sulphuric Acid, ...	1·00
Phosphoric Acid, ...	——
	99·88

Having stated, thus shortly, the conditions under which Cone-in-cone occurs at Waterland, I shall now proceed to describe its external and internal characters, as displayed by specimens from that locality, and afterwards I shall endeavour to describe what I believe to be some of the conditions under which the structure itself was formed. In order, however, to illustrate what I have to state—first, regarding the external form of the cones, and, second, their internal structure—I may mention that I have used for the first proposition specimens in which the cones have been fractured vertical to their length, and in which the transverse corrugations are well seen on the surface; and for the second, upwards of two dozen vertical sections selected from different specimens, and ground to a thin transparency, so as to show the internal structure of the cones throughout all their length, from their commencement to their finish, as well as the variations in development which exist between the cones of one specimen and those of another. Upon these sections I rely strongly, as supporting the conclusions I had previously formed from the study of the external characters of Cone-in-cone structure in specimens showing only the outer surface.

In the first place, I may here state, in regard to the form and arrangement of the cones, that there can be no doubt of the fact, as seen in my specimens, that the apices are invariably turned to the under or lower side of the stratum, while their bases are as invariably directed to the upper surface. I have never

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seen any specimens of Cone-in-cone to justify the statement, quoted from Geikie's edition of Jukes' Manual of Geology, that the bases of the cones are "at top and bottom of the seam, and their apices pointing inwards towards each other." I am inclined to think that such a description is due to faulty observation, or could only have been made from a badly-preserved specimen, in which the structure was obscure or much confused. From the quotation given from Dr. Sorby's paper, it seems to me that he also has fallen into a similar mistake when he states that the apices start "from a well-defined plane, and after extending upwards or downwards for a greater or less distance, with their axes perpendicular to the plane of stratification, they end in bases parallel to it." I hope to show by and by that such an arrangement of the cones, as illustrated in my specimens, does not exist, and could not take place, as the action was one which proceeded upwards from the base of the stratum, and terminated ultimately on the upper surface of the bed.

In transparent sections of Cone-in-cone from Waterland, the apices of the cones are seen to terminate downwards at distances varying from one quarter to one half inch above the lower surface of the bed. Below the point where the cones terminate, the bottom layer has a confused, undulating structure, in which the original stratification of the deposit is in most cases obliterated, but at the point where the cones commence, the sections show the beginning of a great number of very small cones—in fact this layer is crowded with them—the bases ascending to varying heights in the stratum, only a limited number of the original cones having ever reached the surface of the bed, and these main or leading cones form a marked feature in all the sections.

The cones in transverse sections are all more or less circular, and of slightly varying diameters, and are formed of successive concentric layers, one within another, throughout the whole length of each cone. Transparent sections show that the lower external layers of the cones never reached the surface of the stratum as it now exists, but that they, in their expansion upwards, interfered with and impinged upon one another, in most cases terminating at the same level; these successive ascending layers, in their junctions with one another, forming a kind of arcading that reminds one of miniature gothic arches. It is very probable that it is this arching, formed by the upward junctions of the layers in the several cones,

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which has deceived some observers into the belief that there were two sets of apices dovetailing into each other, viz.—the true apices, and the pointed arches formed by the junction of the ascending layers, but it only requires an examination of vertical transparent sections to show that such was not the case.

Nearly every author who has written upon Cone-in-cone structure has referred to the transverse corrugations seen on the surface of the several layers of the cones, but in none of the descriptions that I have read has any explanation of these corrugations been given, nor is any notice taken of a thin film of clay which also coats the vertical surface of these concentric layers, and to which their ready separation from one another is due. I have found that this thin coating of clay exists in all the Cone-in-cone specimens that I have been able to examine, and in the transparent sections from Waterland it is seen to mark off the several calcite layers from one another, by nearly opaque black lines of clay of varying thickness. Sometimes the clay coating is of extreme thinness, at other times it is as thick or thicker than card paper; but thick or thin, it always has a tendency to form weak lines between the layers, and to cause in them a ready vertical separation of the cone structure in most instances. Tangential, or cross sections of the cones, especially when taken near the surface of the bed, also show very clearly this film of black clay, in thin, ring-like lines, surrounding the concentric layers. I shall again refer to this important character when stating what I believe to be the mode of formation of the cones, and shall now only notice shortly one other external character exhibited on the surface of our best-preserved specimens.

In many of the specimens from Waterland, as well as in those from the pit near Paisley, if we examine the upper surface of the Cone-in-cone stratum, we see that the bases of the cones terminate in a series of small, ring-like elevations, one within another, the innermost being generally the highest and often less than a line in diameter at its summit. These small cones vary from one to six or more in number within the base of each larger cone, and they often rise from one eighth to one quarter inch in height above the general level of the stratum. These little elevations are seen in the transparent sections to be the bases of smaller cones, the apices of which, like those of the larger ones, are always directed downwards in the stratum. In some of the specimens that I exhibit, and which have weathered for some time upon the shale heaps at the quarry, the

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small inner cones have in many instances fallen out from the bases of the larger ones. In these specimens the surface of the cone stratum presents the appearance of small groups of irregular, ring-like, conical craters, strongly reminding one of the appearance of the moon's surface as seen in photographs, a resemblance which has, independently, suggested itself to different observers of these specimens.

I have no doubt that the characters here indicated were present on the surface of every Cone-in-cone stratum, but it is only when preserved under perfect conditions like those from Waterland that these small terminal cones are ever seen, they being generally adherent to some hard, overlying bed, to which the stratum is firmly attached, and by which the bases of the cones are concealed.

Thus far I have endeavoured shortly to describe some of the external and internal characters observable in the specimens of Cone-in-cone from Waterland Quarry, and I shall now proceed to refer to what I believe were the agencies that originated the structure. I have endeavoured by careful study of what has previously been written on the subject, to find an explanation of the structure as it is now seen to exist in these specimens, but I have failed in finding any one satisfactory to my mind. For instance, I can find nothing in the structure of Cone-in-cone to warrant the assumption that it was produced by pressure acting on concretions, or from pressure acting on the stratum in any other shape; nor that it is the result of any chemical precipitation from the waters in which it was formed, nor of a concretionary or other form of crystallization in the stratum after the bed was deposited. My specimens show external characters and points of structure which apparently go against all these suppositions, and although the explanation I intend to offer is one that is satisfactory to my own mind and seems to meet all the requirements of the case, I do not assert that it is the only explanation that might be suggested, for I may have overlooked, or may not have properly understood, some of the agencies which conduced to the formation of the structure.[1]

[1] During the progress of my investigations I have had the opportunity of submitting my specimens and sections of Cone-in-cone to Dr. Young, Honorary Member, Professor of Natural History and Geology; to Mr. Ferguson, Professor of Chemistry; to our President, Sir William Thomson, Professor of Natural Philosophy; and to his brother, Dr. James Thomson, Professor of Engineering (in the University of Glasgow), the latter of

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Cone-in-cone, as it appears to me, is the result of a mechanical action, set up by chemical agencies, in the stratum in which it is found, and whilst the deposition of the sediment was going on, as I hope to point out more fully later on. It is also a structure, so far as I have seen, that does not affect in the least either the immediately underlying or overlying stratum, and is confined vertically to the thin bed in which it exists, but it may, and does, extend horizontally with the bed over wide tracts of country, as I have already pointed out.

The chemical agencies which seem to have set up the mechanical action in the stratum appear to me, after a careful examination of all the phenomena presented by Cone-in-cone, to have been the outward and upward escape of gases generated probably by the decomposition of organic matter in the deposit. These gases, as they slowly escaped upwards through the oozy and plastic mud, elevated the sediment around the several points of eruption into conical, ring-like layers, the last feeble ebullitions being indicated at the upper extremities or bases of the cones by the little conical eminences, already referred to, which now rise above the regular surface of the bed. With the cessation of the escape of the gases from the underlying sediment the structure ceased to be further extended, although deposition of sediment, apparently of the same mineral composition, still went on in the waters in which the stratum was forming.

It may here be of interest to indicate the nature of the evidence which seems to me to show that the cones were formed while the sediment was still in a highly plastic state. I have already stated that the structure generally commences at a short distance above the base of the stratum with a numerous group of very small cones, each of which in transparent section is seen to have an independent tube or axis of eruption through which was elevated the sediment in inclined layers to the then existing

whom has given much attention to structures in various rock substances, and I am glad to be able to state that so far as my specimens are concerned they are all inclined to agree with me in considering that neither crystallization, pressure, nor chemical precipitation, had anything to do with the formation of the cones, and that to their minds the explanation I have given of the several points of structure being due to the upward escape of gases through the sediment, appears the most probable one, and fully explains the appearances of the various specimens.

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surface of the bed. As the stratum increased in thickness, many of these small first-formed cones also increased in size, but the greater number became extinct, and were buried gradually under the higher and more extended layers of the more powerful cones that continued in action to nearly the close, when the structure ended, as we now see, in a group of small but feebly developed cones.

I have pointed out, as characteristic of Cone-in-cone structure in my specimens, the existence of a thin layer of argillaceous mud, apparently unnoticed by previous observers. This separates the calcareous layers, and appears to have been deposited on the inside surface of the cones during the period between one ebullition of gas and another. That these ebullitions occurred at varying periodic intervals seems to be clearly indicated by the varying thickness of the films of clay and layers of calcareous sediment which build up the cone structure. But there is another important character connected with this layer of clay to which I wish to refer, as it bears strongly on the question of the successive formation of the calcareous layers of the cones while the stratum was being deposited. When these dark lines of clay are carefully examined in transparent and vertical sections of the rock they present on their lower surfaces a corrugated or serrated structure, corresponding exactly to the transverse wrinkles or corrugations which, as I have already stated, are to be found on the inner surfaces of all the cones.

If we further examine these black lines of clay, we see that their upper surfaces are never corrugated or wrinkled in any degree, and that they always present an even or comparatively smooth face or slope upon which the next calcareous layer rests. This important character points strongly to the conclusion that the transverse wrinkles seen on the surface layers of the cones were produced by a creeping downwards through gravitation of each of the successive calcareous layers whilst still in a semi-plastic state, and while thus moving downwards the surface film, which had then begun to harden, was dragged into a series of minute corrugations, the number and depth of which are frequently seen to correspond with the size of the cones and the plasticity and thickness of the layers. Similar corrugations to those seen in Cone-in-cone may be often observed where a thin layer of tar, pitch, or thick oil paint has been spread upon a sloping surface.

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The outer film in such substances hardens more quickly than the inner portion, and as the layer creeps slowly down the inclined plane through gravitation, the hardening surface is dragged into a series of corrugations, they being, like those of Cone-in-cone, always at right angles to the slope along which the substance was moving. Had this wrinkling of the surface of the cones been produced by any other known agency at some after period of time, we should naturally have expected that the dividing black lines of clay would also have been corrugated, but this is clearly seen not to be the case. In my view the formation of the cone structure seems to have gone on in something like the following manner. In each successive ebullition of the gases which elevated the plastic sediment around the axis of the several cones there were pauses, of longer or shorter duration, the cones meanwhile remaining open at their bases or at the points where their ascending layers terminated at the then existing surface of the deposit. It was during these intervals that the corrugation of the upper or inner surface of each calcareous layer seems to have taken place, and on which the separating film of clay was afterwards deposited from the waters in which the stratum was formed.

The transparent sections which I have prepared clearly show, I think, that the argillaceous mud settled down in each case upon an already corrugated surface, the lower face of the film of clay thus entering in and filling up all the wrinkles, and forming a counterpart or cast of the corrugations, while its upper or inner face afterwards came to present a smooth, even slope, on which the next ebullition or layer of calcareous sediment was deposited. We have thus in our Cone-in-cone structure an alternating series of calcareous and argillaceous layers, each calcareous layer resting upon a smooth face of clay, while the clay layers in their turn rest upon the corrugated surfaces of the calcareous layers. When the calcareous layers are examined in transparent section, under a low power of the microscope, it is seen that the calcite has arranged itself in fine lines, having a semi-crystalline structure, running nearly parallel with the angles of the cones. These lines are crossed at acute angles by other equally fine lines or fissures, and the junction of the two gives a peculiar chevron-shaped or zig-zag structure to the layers, probably due to some crystalline action set up in the calcareous sediment after deposition, but it evidently had nothing to do with its arrangement within the

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cones. Many of the sections also show under the microscope that the thin layers of separating clay, ere they had properly consolidated, had been broken up into small pieces and granular fragments, which had been moved from their places by the eruption of the succeeding calcareous layer. We also find these broken-up lines of clay existing between others that are still intact, which shows, I think, that there was some variation in the force or action, and in the period of time between the formation of each layer. I also find in some sections, especially in one from a pit near Paisley, the curious feature that they have their fine lines of calcite dragged or bent backwards into the cone from the weight of clay in some of the layers pressing down the crowns of the corrugations in the calcareous layers, and that seemingly ere they had been properly consolidated—another strong proof, I think, that these layers were in a plastic state when erupted.

I cannot call to remembrance any known form of crystallization, chemical action, or pressure, forming such a structure as that here described, but I think its formation by the method I have attempted to explain is a probable one, and does not go beyond the possibilities of the case. There are other facts which point to the calcareous layers having been elevated by a force acting from below, one being the occurrence, in some specimens of Cone-in-cone, of small fish coprolites which are sometimes seen to plug up the orifice in the central axis of the cones, and to distort and otherwise interfere with their formation; whilst in others, fragments of shells of *Anthracosia* have been elevated so as to coincide with the angles of the layers of the cones. It may be of interest also to note that where shells or coprolites exist in the bed, the Cone-in-cone structure does not exist in these fossils, as might be naturally expected would not be the case under the method of deposition I have pointed out, for they being hard bodies when the calcareous layers were being elevated, the upward tendency of the several ebullitions would be to heave them to the surface of the bed as ejectamenta. It is also seen in many specimens that the bases of the cones, as they reach the surface of the bed, and where the pressure of sediment on the gases would naturally be less, expand somewhat suddenly, the cones thus becoming trumpet-mouthed in shape and the reflexed layers folding over and spreading so as to touch or unite with those of other cones.

When a vertical transparent section is made so as to cut

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through the central axis of any of the cones, there is always seen a narrow dark column of clay somewhat less than a line in breadth, extending upwards through the whole length of each cone, and into this column converge all the lines of clay which separate the calcareous layers. The latter, thus, do not touch one another at their extreme apices, and it appears to my mind as highly probable that this orifice or tube from below, through which each succeeding calcareous layer was ejected upwards, was kept open on the line of this central axis during the formation of each cone. There is also another interesting character revealed in transparent sections, showing how the layers of clay were deposited. On examination of these sections, it is seen that during the formation of the deposit there were often interspaces between the bases of the cones as they then existed, and that upon those flattened interspaces, consisting of small heights and hollows, the layers of clay not only rested thicker than upon the inner slopes of the cones, but were often continuous with them. In the sections this character is seen to become more conspicuous as it reaches the upper surface of the bed, for there the cones are often less numerous, and the interspaces between their bases broader than in the earlier stages of the deposit. This clay apparently does not differ either in colour or texture from that which continued to be deposited in the immediately overlying bed, and in which, as formerly stated, Cone-in-cone structure does not exist.

There is one other character revealed in the specimens from Waterland to which I wish to direct attention, as indicating clearly, I think, the formation of the cones while the stratum was still in a soft, plastic condition. It will be seen from some of these specimens that the structure is only very feebly developed, or is sometimes entirely absent, in those portions of the stratum where the bed becomes thin, indicating, as it were, that it required a certain thickness of sediment to be sufficient to generate gases powerful enough to elevate it into distinct conical layers. The upper surface of the stratum, in these thinner portions, is generally smooth, or presents a slightly blistered appearance. In such slabs we sometimes have the curious phenomenon presented of a few widely and irregularly scattered cones of varying sizes, appearing on the surface at intervals, and which in other examples form a united chain of cones extending across the face of the

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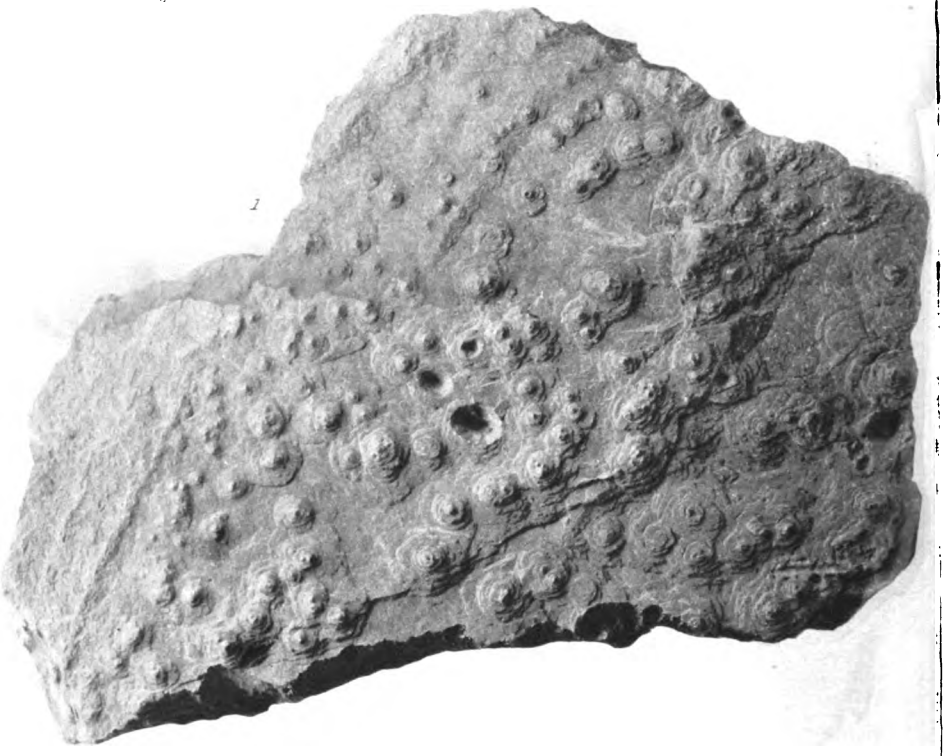
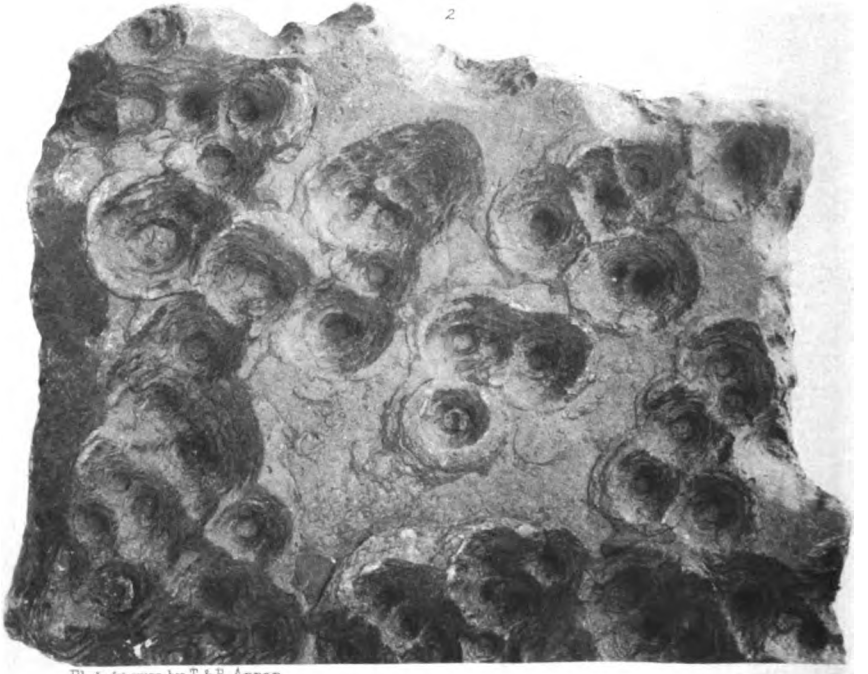
Pl. I.





Photogravure by T. & R. Annan.

Illustrations of Cone-in-cone structure.

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NOTE.—At the time when these notes on Cone-in-cone structure were written, I was not then certain whether I might be able to get any illustrations of the structure prepared to accompany the paper, hence there has been no reference in the text to figures or plates. I was anxious, if these were given, that they should be produced by some process that would faithfully represent only what the specimens themselves displayed. I have, therefore, been fortunate in getting my friend Mr. Thomas Annan interested in the matter, and he has kindly taken the photographs of several specimens, some of which are reproduced in the two following plates by his new photogravure process; and I here take the opportunity of thanking him for the care and time he has bestowed upon them. I am only sorry that I have not been able to get more illustrations done, as it would require more than is given in the plates to illustrate all the characters of interest that I have noted in the paper.

EXPLANATION OF PLATE I.

FIG. 1 illustrates, slightly reduced in size, the upper surface of a specimen on which the cones are seen to increase in diameter from the left to the right hand side, or to that side in which the stratum is thickest. It also shows the raised and ring-like bases of the cones at the point where they terminated on the surface of the bed, as more fully explained on pp. 10, 11, 16, and 17 of the paper.

FIG. 2 illustrates, natural size, the upper surface of another specimen, in which the raised terminal layers of the cones have fallen out from the surface of the stone through the effects of weathering on the shale heap (pp. 10, 11). These openings also show, at their base, in all the cones, the central axis or tube through which the sediment was erupted, several of these being visible in the illustration (pp. 12, 15, and 16). This illustration further shows the ring-like structure of the cones, and how their forms are interfered with in those portions of the bed where they are crowded together (p. 18).

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EXPLANATION OF PLATE II.

FIG. 3 illustrates, enlarged one diameter, a transparent vertical section of the cone structure. In this section the central axes or tubes of several of the larger cones are exposed throughout a portion of their length. They appear as vertical dark lines in the section, into which converge the dark lines of clay that separate the lighter coloured calcite layers of the cones. The section also illustrates the arched structure that exists between the cones, by the junction of their successive ascending layers (pp. 9, 10, 15, and 16).

FIG. 4 illustrates, enlarged one diameter, another transparent vertical section of the cone structure, in which is exposed a portion of the lower part of the axis of a powerful cone; from this spring the axes of several independent cones, which, before the specimen was cut, formed a cluster of small cones at the surface of the bed that surrounded the main or central axis (pp. 10 and 24). This section, and that of fig. 3, also illustrate, in many of the dark clay lines, the notched and serrated character of their lower edges, this being due to the transverse wrinkling of the inner upper surface of the calcite layers upon which the lines of clay were subsequently deposited (pp. 13-15).

FIG. 5 illustrates, natural size, a vertical section, showing how the bases or broad ends of the cones expand as they reach the surface of the bed, owing to the gradually lessening pressure of the sediment upon the gases in their escape upwards (pp. 15 and 24).

FIG. 6 illustrates, natural size, a vertical section of a thin portion of the cone stratum, in which the cones are seen to be very numerous and small in the lower portion of the bed, and also shows that only a limited number of these ever reached the surface (pp. 12, 13). This specimen, and that of fig. 5, illustrate on portions of the surface of their cones the transverse wrinkling noted in pp. 13-15.

N.B.—The specimens used for the illustrations were obtained from the quarry at Waterland.

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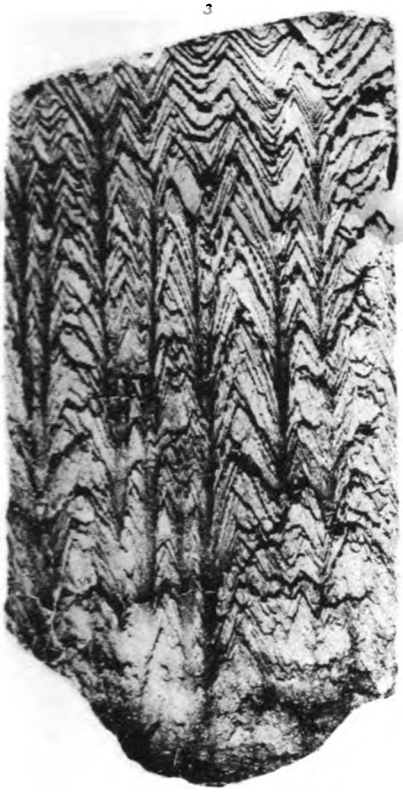

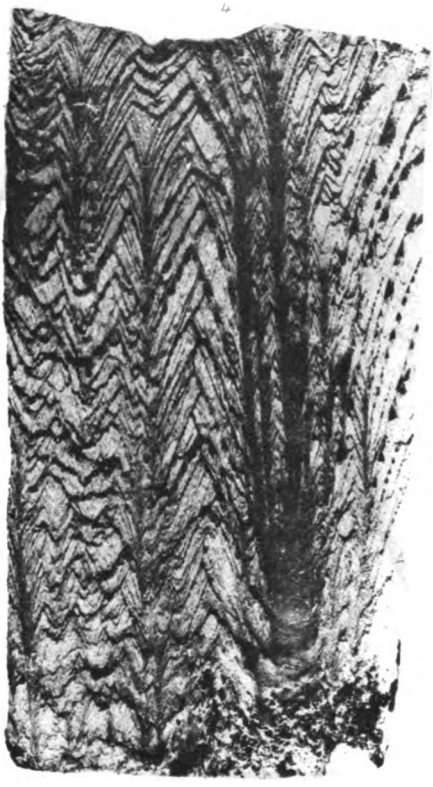

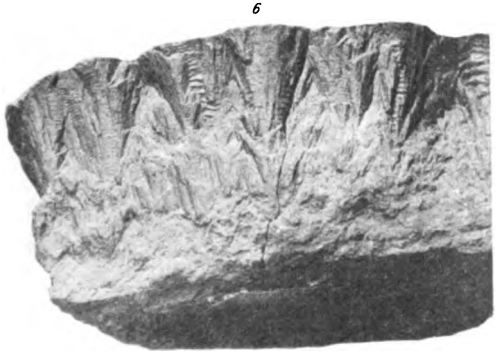

Photogravure by T & R Annan

Illustrations of Cone-in-cone structure

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specimen like a miniature range of low hills. These cones rise from one eighth to one quarter of an inch above the general surface of the bed, and show in a very distinct manner how the various ring-like layers of sediment were piled up, one layer within another, by the action of the escape from below of the gases at these several points.

If I am right in my conjectures as to the agencies which produced the Cone-in-cone structure, then its cessation in any particular bed might be brought about by the sediment ceasing to give off the gases generated by the decay of the organic matter in the deposit, and this would probably be hastened by the disappearance from the waters of the organisms to which the generation of the gases were due. In the case of the Cone-in-cone from Waterland, to which I have so often referred, it is seen that the Entomostraca so abundantly present in the bed, as also the fishes, ceased in a great measure to exist in the waters of the locality whilst the overlying strata were being deposited, and we have as yet no evidence of the recurrence of several of the Entomostraca in any higher strata.

In most of the other Cone-in-cone specimens obtained from the Scottish coalfields, I have also been able so far to connect the structure with the presence of organic matter in the deposits, and to some of these specimens I will now shortly refer. They are all contained in the Hunterian Museum collection, and have either been collected by myself or given by donors. First is a specimen polished on one face and representing two layers, the lower a musselband, full of the shells of *Anthracosia*, on which rests the Cone-in-cone layer 5½ inches in depth. Both layers are highly calcareous and of a light grey colour. The cones are well developed, and some of those that reach the surface of the bed measure 1¼ inches in diameter at their base. In this specimen the cone structure is confined exclusively to the upper layer, the apices of the cones resting on the shell-layer, but not passing downwards into it. There is no locality attached to this specimen, but it seems to be identical in colour and composition with another specimen in the Museum, from Auldton Colliery, near Larkhall, Lanarkshire, the working being in the upper coal measures. In this the cone structure is also 5½ inches in height, but the musselband layer at the bottom is absent or broken away. In both of these specimens the transverse corrugations on the surface layers of the cones are

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beautifully marked, the film of clay separating the calcareous layers being of a bluish-grey colour in newly fractured examples. In the polished specimen, it is seen that this clay fills up the corrugations exactly after the manner of those already described from the bed at Waterland. I think it is clearly evident that the Cone-in-cone structure has here been formed through the action of the gases generated by the decomposition of the *Anthracosia* in the lower portion of the stratum. In another specimen from the Airdrie coalfield, in which the cone structure is incumbent on a stratum of blackband ironstone, we find that the organisms which generated the gases were chiefly those of plant remains and fishes. The cone structure is here 7½ inches in height, the stratum being only very slightly calcareous, and of a black colour, while the texture is somewhat coarse; hence, the transverse corrugations on the surface layers of the cones are not so distinctly marked as in those composed of the finer-grained calcareous sediments. The layers of the cones are, however, separated by the usual film of clay, and as the cones ascend to the surface of the bed, these layers, in the several cones throughout the 7½ inches in height, are seen to continually impinge upon one another, only those in the upper portion ever reaching the surface of the bed.

In another specimen, presented by Mr. Robert Craig, from Davies Hill, Dalry, and from the same geological horizon as those from Waterland, we find the Cone-in cone structure 7 inches in height, the individual cones being few, and very large, some even, where their bases reach the surface of the bed, measuring 2½ inches in diameter. Owing to the large size of the cones, the several calcareous and thin argillaceous layers which build up their structure are very clearly displayed, as well as the varying thickness of the calcareous layers, due, I think, to the varying power in the ebullition of the gases by which the sediment forming the layers was erupted. It is interesting to note in this specimen how these layers had their edges truncated or interfered with on one or more sides of the cone, by coming in contact with the opposing layers of more powerful cones, by which they are often overlapped and buried. It also illustrates in a clear manner the structure of the thin layers of clay which separate the calcareous layers, the distinction between the two being brought out more strongly on its weathered face, where the calcareous layers have been bleached from a dark, blackish-grey into a light, yellowish-

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grey, the lines of separating clay being unchanged, and of a deep black colour. These thin layers of clay are of varying thickness, but when viewed in section they all show, in a very beautiful manner, the serrated character of their under edges, these serrations, as formerly stated, being the counterpart of the transverse corrugations seen on the inner upper surface of the several calcareous layers of the cones, the wrinklings of each layer taking place while it was in a soft and plastic state, and the thin film of black mud being subsequently deposited from the water upon the corrugations of the cones.

In another specimen from Hunter's Hill Pit, Bishopbriggs, north of Glasgow, and on the same geological horizon as that last noticed, but distant at least twenty miles in a straight line from it, we have a Cone-in-cone structure developed in flat, nodular-shaped masses in a clay carbonate of iron. The cones are about three inches in length, and as their bases reach the surface of the bed they suddenly expand, their layers folding outwards so as to give the cones a kind of bell shape. These cones are well formed, and have the usual corrugated surface, with films of clay separating the layers. In another pit near the Barracks, Maryhill, and about three miles westwards from Bishopbriggs, we find the same Cone-in-cone stratum existing. Here also it occurs in flattened, nodular-shaped masses, in an impure and very coarse kind of clay-ironstone. The cone structure is rarely visible on their external surfaces, but when broken up they show all the usual characters, viz., the corrugated layers and the separating lines of black clay, though in a very imperfect and ill-formed condition. It appears to me that the less perfect development of the cone structure in this locality is chiefly due to the coarser sediment in which the structure has been formed, it being composed of a black, arenaceous and ferruginous mud, in which very little calcareous matter exists. The cone structure is further obscured by the twisting and crushing of its layers through vertical pressure, after the cones were formed, many of them being completely squeezed into a mass of confusion, instead of standing erect in the bed. The only organisms I have noticed in connection with the structure at this locality are fragments of plant remains and coprolites of fishes; but they seem to be rare, and this scarcity of decaying organic matter in the stratum whilst it was in the process of formation, may, through the feebler

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ebullitions of the gases generated, have prevented a more perfect development of the cone structure.

I have to notice also two other specimens of Cone-in-cone from our upper coal-measures in connection with organic remains—one from a pit put down some years ago near Provanhall, a few miles east of Glasgow, and the other, recently presented by Mr. John Kirsop, from the Gilbertfield pit, also east of Glasgow. Both of these specimens formed portions of large flattened, nodular-shaped masses, and both probably from the same horizon of strata. The former has the cone structure 4 inches in height, some of the cones at their bases measuring nearly 3 inches in diameter. The cones are finely formed, the transverse corrugations on the surface of the layers being large and deeply marked, whilst the colour of the cones is of a deep shining black, due to the dark carbonaceous clay by which their surface is coated. A few shells of *Anthracosia* are also to be seen in the lower portion of the stratum. In the specimen from Gilbertfield the larger cones are 2 inches in height, but in one portion the formation of the cone structure is somewhat interfered with by the *Anthracosia* shells present. I have already stated that where large shells or fish coprolites are present that they always show interference with the formation of the cones, the structure in transparent sections apparently not passing through these organisms, as I think it would have done, had it been due to either crystallization or pressure at some subsequent period. Mr. Thomas Naismith has also recently presented me with some very fine examples of Cone-in-cone from the same horizon of the upper coal-measures to the east of Glasgow. The point they illustrate is the connection of the structure with the shells of *Anthracosia*, whilst the specimens also show in a very beautiful manner the corrugated surface of the cones, and the way in which the more powerful and later-formed cones have interfered in their layers one with another in their upward growth to the surface of the bed.

The only other example of Cone-in-cone that I have been able to examine, except those already noticed from the Western coal field, is a specimen from the Lias formation of Whitby, presented by Mr. D. C. Glen, F.G.S. In this example the cone structure measures $3\frac{1}{2}$ inches in height, and is well developed, the cones expanding rapidly and some of them at their bases measuring $2\frac{1}{2}$ inches in diameter. The rock is of a dark grey colour, and is

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composed of two distinct series of layers, viz., layers that are strongly calcareous, and layers that are argillaceous, and not affected perceptibly by acids. In the specimen under notice, the transverse corrugations are well marked, being large on the larger cones and small on the smaller; and it is clearly seen that they are, like those previously noticed from our Carboniferous strata, confined to the inner face of the calcareous layers of the cones. The clay that separates the calcareous layers is of a darker colour than they are, and glistens with minute scales of mica; and also shows in sections of its lower surface similar serrations to those seen in the Carboniferous specimens. I do not know the conditions under which this Cone-in-cone bed exists in the Whitby Lias, but as far as my specimen shows there is no trace of organisms in connection with its cone structure, though they may exist in the underlying stratum, as is seen to be the case with most of those from Scottish Carboniferous strata. It has evidently been broken from a shore bed which has had its upper surface abraded by the action of the waves; but this surface shows clearly that the cone structure terminated in the stratum with a group of smaller cones similar to those seen in the specimens from Waterland previously noticed, and I am further pleased to observe in it that all the characters agree in every detail with those from our Carboniferous strata.

In bringing these remarks to a close, I have only further to observe shortly that I do not know of any instance of Cone-in-cone structure being found in connection with undoubted marine deposits in Scotland, such as the limestone strata. I do not assert that such does not exist, but so far as the evidence goes the organisms found in connection with the Scottish specimens indicate freshwater conditions for the beds, and, from the extent of country over which these are known to extend, lacustrine rather than estuarine conditions of deposit.[1] I have already stated

[1] Recently our member, Mr. James Bennie, of the Geological Survey of Scotland, kindly sent me two specimens from a band of Cone-in-cone from 4 to 6 inches in thickness, which occurs in connection with a bed of soft earthy shale some 7 feet in thickness, at a point on the Fife coast near St. Andrews, known as the "Witch Lake." Mr. Bennie states that throughout this shale bed on which the cone stratum rests there occur marine organisms, but not in very good preservation. The cone stratum exists as two layers, being parted by a seam of fine encrinal debris, varying from 1 to 2 inches in thickness, but into which the cone structure does not extend from either of the layers. This encrinal debris has all the appearance of

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that Cone-in-cone structure is not everywhere well developed or indeed even always present over the whole area in which the stratum is found. The presence or absence of development may perhaps be difficult of explanation, being possibly due to one or more of several causes, such as depth and temperature of the waters in which the structure was formed, and to differences in the composition of the sediments at various parts of the area of the old lake bottoms. These variations of conditions may also probably have acted upon the distribution of the organic life in the deeper and shallower tracts of water, and may also have acted in some instances in hastening or preventing decomposition of the organic sediment, and thus altering the action of those gases to which I think the origin of the structure was undoubtedly due. Another point to which I would like to advert is that while the structure in all the specimens I have examined presents identical characters, yet there are variations between the mineral composition of one stratum and another. Some Cone-in-cone structures are so strongly calcareous that they might be considered impure limestone, while others are more argillaceous and ferruginous, with only a small percentage of lime in their composition.

I have never met with Cone-in-cone structure in Scottish beds showing any tendency towards an oolitic character, neither is it seen in the Lias specimen noticed. I do not, however, assert that oolitic structure may not exist in some varieties of Cone-

having been drifted from a deeper tract of the sea-bottom into shallower water where the cone structure was forming, and although under marine conditions, these seem to have been such as favoured the escape of gases from the decaying organisms in the bed. The argillaceous deposit in which the cone structure exists is of a somewhat coarse texture, the cones therefore not being so finely developed as we find them in finer grained sediments. From what Mr. Bennie points out as to the nature of the strata in which this marine bed is intercalated, I think they are such as strongly favours the assumption that we have here a series of deposits comprising old land surfaces, and freshwater or lacustrine beds alternating with marine ones. The strata are as follows—Sandstone and sandstone shales; grey shales and fireclays, with sandstone containing *Stigmaria;* coal with shale intermixed; marine shale with stratum of Cone-in-cone; ironstone nodules and limestone bands; fireclay, black coaly shale, coal, and sandstone with coal and shale. This interesting section is the first in which I have seen Cone-in-cone associated with undoubted marine remains, although the bed has all the appearance of having been deposited in what may have been a marine swamp.

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in-cone, but I cannot accept Dr. Sorby's view that the formation of Cone-in-cone proceeded after the same plan as that which he states he had been able to ascertain, through the crystallization of "some kind of oolitic grains," for I have already shown that the Cone-in-cone structure under notice is composed of two distinct sediments, alternating with each other in the several layers; and further that the cone structure, with all its attendant phenomena, must have been formed ere the crystallization seen in its calcite layers was set up—this crystallization and that seen in oolitic grains having both been effected since the deposition of their strata.

From what I have read regarding some of the so-called Cone-in-cone structures already described by authors, I am much inclined to believe that they are not all genuine Cone-in-cone—for instance, that called the "beef-beds" and that said to be found in some "coals." I think if such were carefully examined that they would be found to differ very much, in their structure, from the Cone-in-cone specimens which I have brought before the Society, and that they were probably formed by different agencies from those I have here noticed.

In concluding, I offer the following as an epitome of the chief points of Cone-in-cone structure as noted in the foregoing pages, and as illustrated by the specimens and sections exhibited. As previously stated, some of these points do not seem to have been formerly noticed or described, and I am therefore anxious that they should be presented to your consideration in as clear and concise a manner as possible. They are as follows:—

1st. That Cone-in-cone structure appears to be due to the upward and successive escape of gases generated in the lower portion of the stratum in which the structure is found, probably by the decay of organic matter in the deposit whilst still in the process of formation and in a soft, sedimentary condition, each ebullition of gas being marked by a new or successive layer of sediment within each cone.

2nd. That Cone structure is seen to be composed of two distinct and alternating series of layers, successively formed within each other as the cones grew upwards; one of these layers being always more or less calcareous and ferruginous, the other layer being argillaceous, and that it is to this difference in the lithological composition of the layers that their ready separation along the vertical lines of junction in the cone structure is due.

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3rd. That the cones, large and small, are seen to have their apices invariably directed towards the lower portion of the stratum, and that near the bottom the cones are numerous and small, but as they grow upwards, from successive increasing layers of sediment, their bases keep gradually expanding until the edges of the several layers, in contiguous cones, impinge on each other, forming a series of acutely ascending arches; or, in cases where the action has been more powerful, overlapping and burying the weaker cones, ere they reach the terminal surface of the deposit where the cone structure ceases. At this point the bases of the cones are seen to expand more suddenly, the layers being slightly reflected outwards, so as to give the broad ends of the cones a trumpet-mouthed shape, this expansion being due, I think, to the lessening pressure of the sediment on the ebullitions of gas as they neared the surface of the deposit.

4th. That the transverse corrugations, or wrinklings, seen on the inner upper surface of the calcareous layers of the cones, appear to have been due to a creeping downwards from gravitation of the gradually hardening surface of the layer of sediment, whilst it was still in a plastic state; and that upon these corrugated, calcareous layers there have been successively deposited from the waters in which the stratum was forming those thin argillaceous layers which now separate the calcareous layers in all the specimens.

5th. That transparent vertical sections show the existence in all the cones of a small central axis, into which all the argillaceous layers converge and unite so as to form a dark-coloured tube, filled by the clay, and that through this orifice of the axis the sediment forming the calcareous layers was successively ejected during each ebullition of the gas from below, the action being comparable to that of a miniature geyser.

6th. That the Cone structure terminates in a series of minor cones planted within the bases of the larger ones, and that where the surface has not been abraded they are seen to rise to variable heights above the general level of the deposit, the smaller cones showing clearly that the ebullition of the gases which formed the larger cones was suddenly decreasing, the ejected sediment being small in amount, and only able to form within the base of each cone a variable number of small, ring-like conical eminences, one rising slightly higher within the other; until in the last, which now forms the central cap or ring in the minor cones, being less in

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bulk than the head of a small pin, the formation of the Cone structure is brought to a close.

Since this paper was read, I have had specimens of Cone-in-cone sent me from three localities in the English coalfield—one from the neighbourhood of Sheffield, by Mr. G. R. Vine, and two from pits in the South Welsh coalfield, by Mr. R. Kidston, F.G.S. I have also been able to examine various other specimens from the Scottish coalfield, but in none of these have I found characters differing from those I have here described, or the formation of which cannot be accounted for by the theory I have set before you.

I may here also take the opportunity of stating that Professor J. S. Newberry, M.D., has recently contributed a short article on Cone-in-cone to the *Geological Magazine* (December, 1885), in which he notices the abstract report of my paper which appeared in the number of that magazine for June of the same year. He there states that "the theory of the escape of gases through a pasty medium" had likewise occurred to him. He goes on to say that when a student at the Jardin des Plantes, Paris, and attending the geological lectures of M. Cordier, who described Cone-in-cone as an imperfect crystallization, he (Prof. Newberry) "proposed to him the theory of the escape of gases through a pasty medium, but Professor Cordier said that would not do, because the points of the cones were sometimes turned upward, sometimes downward." Professor Newberry next refers to the numerous opportunities he subsequently had of observing Cone-in-cone in various localities, and in many geological horizons, whilst conducting the surveys in several of the American territories. He says —"More generally the Cone-in-cone structure is observable in lenticular sheets of earthy limestone or shale impregnated with lime, and in each sheet the cones are usually turned in the same direction, oftenest with the points down, but sometimes turned upward, and occasionally turned in both directions." After referring to examples in which the cones are seen to be divergent around the surface of nodular masses, he states, in conclusion, that "such specimens as these I have described seem to me to be incompatible with the theory that Cone-in-cone is caused by pressure or the escape of gases, and appear to confirm the conclusion that it is due to an impeded tendency to crystallization."

Remarking on this, I have only to state that neither Professor Newberry nor any of those who have adopted a crystallization theory

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for the formation of the cones have offered any explanation as yet of any known law of crystallization which would satisfactorily account for all that is seen in the internal structure and external characters of the best preserved specimens of Scottish Cone-in-cone, such as I have described. If the structure is due to an "impeded crystallization," I would ask those who support this theory, what would have been the ultimate form and internal structure of the cones had the crystallization in the stratum been carried on farther, or to its fullest extent? It is strange that in all the localities and countries of the world where the structure has been observed, the agency by which it was formed has always stopped at a stage corresponding with the complete formation of the cones. If, on the other hand, we view the structure as due to the action of chemical and mechanical agencies, then we see that it is as perfect in all its details as we could expect it to be from the operation of such agencies. Professor Newberry's remarks, however, do not offer any explanation of the structure, being wholly confined to the evidence derived from the direction in which the points or apices of the cones are turned in the bed; and as some of his examples differ much from anything that has come under my observation, they are beyond discussion in the present paper, and will have to be described with reference to their external characters and internal structure.

In all the lenticular and nodular masses of Cone-in-cone from our coalfields that have come under my notice, the cones have only had a very slight inclination from the perpendicular or normal position they usually assume in the bed. Where any radiation is seen it is usually in these lenticular masses. In a level, continuous stratum the cones are always vertical. On thinking over the causes that may have led to this outward bending of the cones, I am inclined to ascribe the arrangement to the contraction inwards and downwards towards a central nucleus of the material forming such masses during the aggregation and solidification of their elements in the sediments in which they are found. In such nodular and lenticular masses as are traversed by septaria, which were originally open contraction-fissures in their interiors, we have a sort of measure as to the amount of surface-contraction that has taken place in nodules without septaria. In the septarian nodules the contraction is seen to have been greatest in the centre and least towards the outer surface, where the con-

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traction-fissures are seldom visible, while in many of those without septaria the contraction is often seen to have taken place by a bending inwards of the upper surface of the mass. As the contraction went on there seems to have been a strong pulling inwards and downwards of the still yielding upper surface towards the nucleus where solidification was going on, the convexity becoming greater and the horizontal area diminishing, until complete solidification had taken place. This contraction of the area of upper surface in nodular and lenticular masses is finely illustrated in the large nodules of clay ironstone found in the section of Carboniferous limestone strata exposed on the hillside at Corrieburn, Campsie. In many of these the upper surface and edges are so much curved inwards that they now have a great concavity in their bases. These nodules do not show any Cone-in-cone structure, but they show such evidences of contraction, internally and externally, as naturally lead us to conclude that where similar nodules exist in a Cone-in-cone stratum the tendency must have been to cause the cones formed in their normal vertical position to assume a radiating inclination around the gradually contracting and aggregating mass. Where the contraction would be greatest, as in the more argillaceous nodules, there may have been a bending, and in some instances a complete inversion of the cones around the edges of the nodules.

This explanation may not suit every case in which the Cone-in-cone structure is seen to be different from that which I have described; but holding the view that the cone structure, in any stratum in which both structures are found, preceded the formation of the nodular masses by a period of time corresponding in length to that required for the aggregation and solidification of the nodules, I believe that, so long as these two forces were at work, we might expect to have had that there were movements in the gradually contracting masses. The amount of radiation in the cones around the curved surfaces may possibly afford as clear an index to the amount of contraction which has taken place as do the septarian fissures in the interior of other nodules.—[Jan., 1886.]

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No. II.—On the Upper Limestones of North Ayrshire, as found in the District around Dalry, and elsewhere.

By Robert Craig, Langside, Beith, *Cor. Mem.*

[Read 8*th January*, 1885.]

Introduction.—The Upper Limestones of North Ayrshire are divided into four distinct series of beds by the intervention of shales and flaggy sandstones, giving to each an independent character, both physically and in extent of area. They are all rich in fossil remains, but, with the exception of the lower bed of the series, they are of small commercial value, and the collector has not therefore the opportunity of searching quarries, as in cases where the limestones are more extensively worked. However, from the openings made by, and the sections exposed in, the various water-courses, a fair collection of their fossils has been obtained, and to all appearance the series are as rich as the Lower Limestone beds, both in quantity and variety of their organic remains. They differ, however, from them in the proportions they contain of the same classes of fossils, as for instance corals and crinoids, in which the Upper beds are poor both in genera and species when compared with the rich deposits of the Lower Limestones. Full lists of the fossils are appended to this paper.

Highfield Limestone.—The first, or lower, bed of the series is a deposit of limestone and calcareous shales known as the Highfield Limestone, from being largely wrought at the place of that name. From a similar reason it is also known in a neighbouring locality as the Swindridge Limestone. It is divided from the Lower Limestone series by about 120 fathoms of strata, which hold the workable coals and ironstones of the Lower Limestones (see *Transactions*, vol. vii., page 86), and lie from 15 to 25 fathoms above the Borestone, or Dalry, main coal. It is of fine texture and is well adapted for iron smelting. Its general thickness is 6 feet, but it is found as thin as 3 feet, seldom rising above the one or falling below the other.

It is found throughout the parish of Dalry, and crosses to the south and south-east of Beith, near Barr. It appears in the Caldwell coalfield, cropping out on the north-east of Lochlibo, near Shelford, Neilston. It crosses into Ardrossan on the south-west, near Girthill, and is seen at the railway station, Ardrossan, nearly on edge and close to the Castlehill. It is found on the south of

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the large fault which runs from Ardrossan up the Dusk and Lugton valleys into Renfrewshire. Crossing into Kilwinning parish, it runs south-east by Goldcraig, Lylestone, and Clonbeith into the south of Stewarton parish. In all these places it has been extensively wrought, and is still worked at the latter place. It is found too in the parish of Galston, and is largely wrought at Moscow and also at Cessnock. Some doubts have been expressed as to whether the limestone worked at these places is the continuation of the Highfield bed, the line of outcrop being broken; but, as it is on the same horizon and bears the same physical and fossiliferous character as the Dalry deposit, it may be accepted as the same until it is proved to be different.

This limestone is almost unfossiliferous,—very few fossils of any kind being found in it,—but both below and above it are associated deposits of calcareous shales very rich in fossils. These shales, with the limestone, have a thickness generally of 12 feet, though this is not persistent, rising sometimes above, and in other places falling below it. The following section taken from the Rye and Caaf Waters, Dalry, shows the deposits at their greatest thickness; the limestone with the shales below it are taken from the Caaf, and the shales above the limestone from the Rye.

	Ft.	In.
1. Shale, calcareous,	2	7
2. Limestone, band,	0	5
3. Shale, highly calcareous,	3	9
4. Shale, calcareous,	2	3
5. Limestone, Highfield,	4	3
6. Shale, calcareous,	3	10
7. Shale, slightly calcareous,	5	1
8. Limestone, band, coarse,	0	10
	23	0

The fossils are more abundant in the shales which partake of a calcareous character than in those which are less so.

The more abundant organisms are—*Productus latissimus*, J. de C. Sow.; *Nucula gibbosa*, Flem.; *Leda attenuata*, Flem.; *Euomphalus carbonarius*, Sow.; *Bucania* (*Bellerophon*) *Urei*, Flem. Of the other shell remains, which are given in full in my list at the end of this paper, one genus or species may be very abundant in one locality and very rare in another, as for instance at Swindridge, Dalry, where *Aclisina* (*Murchisonia*) *striatula*, De Kon., is

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very abundant, while at Girthill, Ardrossan, it is rare, and *Pleurotomaria monilifera*, Phill., is abundant. With this variation in distribution the same classes of shells are found throughout the whole extent of the deposits. Crinoid remains are found in the highly calcareous shales of the deposit, while corals, though present, are rather rare. Fish remains, in scales and teeth, have been found at Swindridge, Highfield, and Goldcraig, though they do not appear to be very common. Still, I believe, from what the small openings in the series have produced, that with the same opportunities of collecting as in the quarries of the Lower Limestone series, an equal abundance of organic life would be found here.

These deposits, which I here place as the lowest of the Upper Limestone series, have a more extended range than any other beds of the series. Although much broken up and full of wants, they are found in their detached basins nearly co-extensive with the Lower Limestone series in North Ayrshire; their line of outcrop being found within that series, but running generally in a parallel line to it.

Hundred Fathom Limestone.—In the pits which lie to the west and south-west of the village of Dalry there is found a coarse limestone, with associated shales, which the pit sinkers call by the above name, from a belief that it lies 100 fathoms above the workable clayband ironstone. It is of no commercial value, and to the palæontologist, as a field for collecting fossils, it is useless. The only surface section with which I am acquainted is one in the Braidly Burn, Dalry, close to a pit that lies to the north of the Cemetery, where it is thrown up by a fault, or break, in the strata, and the following section, taken in ascending order, is exposed :—

	Ft.	In
1. Limestone, fossiliferous, ...	—	7
2. Shale, unfossiliferous, ...	2	6
3. Limestone, fossiliferous, ...	4	3
4. Shale, part fossiliferous, ...	6	6
	13	10

The few fossils that can be picked up are, from atmospheric influences, useless for the cabinet, but not destroyed beyond identification. The limestones and the lower half of the higher shale

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hold the following shell remains:—*Athyris ambigua*, Sow.; *Orthis resupinata*, Mart.; a few species of *Productus*, and *Spirifera trigonalis*, Mart.; but all very fragmentary and fragile. Indeed, but for making my paper as exact as possible in giving the calcareous beds of the upper series, it was scarcely worth while to include this deposit as one of the Upper Limestones. It appears to be of very limited extent, and is wholly confined to a small area around Dalry. It lies 11 fathoms above the Highfield Limestone.

Lower Linn Limestone.—Between the Hundred Fathom Limestone and that known as the Lower Linn Limestone lie about 24 fathoms of flaggy sandstones and arenaceous and clay shales, holding a few badly-preserved plant remains, but otherwise of no value. Resting upon these strata is the Lower Linn Limestone, which, in its greatest thickness, with its associated shales, is 36 feet. This measurement is taken from the pits on the Linn and at Langlands; but good sections of the shale, below the limestone, the latter being reduced in thickness, are to be seen on the Caaf Water both above the bridge near Linn and farther down the stream.

The shale here, lying below the limestone, and which has a thickness of about 6 feet, rests upon a thin seam of coal, and is very fossiliferous; but the fossils are very fragile from exposure to the weather, and few cabinet specimens are found. The most abundant are *Athyris ambigua*, Sow.; *Orthis resupinata*, Mart.; *Productus latissimus*, J. de C. Sow.; *P. longispinus*, Sow., var.; *P. semireticulatus*, Mart. Fragments of *Phillipsia Eichwaldia*, Fisch., are found, but appear to be rare.

Sections of this shale, holding the same fossils, are found in the Rye Water. Resting upon it lies the Lower Linn Limestone, reduced to 13 feet in thickness, and consisting of a series of thin-bedded limestones, being little better than indurated calcareous shales, full of nodules of carbonate of lime, the beds running from 6 inches to 18 inches in thickness. Being of no commercial value, they are not worked, and hence there is no good opportunity of testing their fossiliferous character. In the sections exposed in the Caaf and Rye Waters, Dalry, organic remains are rare; while in those in Monkcastle Glen and Lugton Water, Kilwinning, and on the sea-shore at Saltcoats, they are entirely absent. In the section on the Caaf a few fossils are found in the nodules of purer limestone, which are got by breaking up those pieces that have

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become disintegrated and have fallen into the water. It is worthy of notice that a specimen of a large variety of *Spirifera trigonalis*, Mart., which I presented to the late Dr. Thomas Davidson, was found in one of these nodules. Other specimens of the same fossil, of good size, have been found, but all of the common type. These, with a few fragments of *Productus*, a few badly-preserved specimens of *Aviculopecten*, and a fragment of a Trilobite, are all that have come under my notice.

Upper Linn Limestone.—At Linn, and in the pits around it, 8 fathoms of shales and flaggy sandstones divide the Lower and Upper Linn Limestones. In other localities, and even 1 mile east of Linn, the shales are much thinner, while at Saltcoats they are absent and their place is filled up by about 40 feet of volcanic rocks. This deposit is of similar character physically to that of the Lower Linn beds. It consists of a series of thin bedded limestones of no commercial importance. The nodules, which are of a purer carbonate of lime, make up nearly one half of the beds, and are sometimes burned by the farmers on whose ground the beds crop out, as at Bourtrapping, Dalry. They make a fair lime for farming purposes; elsewhere they are only worked for road metal.

The following is a section as found at Linn Spout, Dalry, from which these beds take their name, but taken upwards:—

	Ft.	In.
1. Coal, from 2 feet to	5	0
2. Shale, indurated, ...	1	3
3. Limestone, ...	1	2
4. Shale (full of shells of *Estheria punctatella ?*), .	0	8
5. Limestone, ...	1	0
6. Shale, very fossiliferous, ...	5	9
7. Limestone, Upper Linn, ...	35	0
	49	10

These Upper Limestones, with the exception of the Highfield or Lower beds, have a limited extension, being mostly confined to a small area around Dalry. They also extend into the north of Kilwinning parish, and are found in the same parish on the Lugton Water much reduced in thickness. I was informed by the late Mr. Danks, mineral borer, that he had bored through them in the south of Stewarton parish where they had a thickness of 30 feet, but I question the correctness of this information.

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Two beds of limestone are found interbedded among the volcanic rocks on the shore at Saltcoats, and these may be the Linn limestones, though it is doubtful. However, they are on the same horizon, and as the section on Lugton Water is contiguous to the volcanic rocks there, these beds may be an extension of the Linn limestones, as the beds of limestone between Ardrossan and Saltcoats, which the Survey put down as uncertain Linn, are the beds of the Lower Limestone series thrown up by a large fault.

The section exposed at Saltcoats, in the harbour, and north of the old Salt Pans, is as follows :—Coal, about five feet; volcanic, "white horse," 2½ feet; volcanic, variety of melaphyre, about 30 feet; limestone, 6 feet; volcanic tuffs, etc., about 40 feet; limestone, 12 feet; volcanic tuffs, dolerites, etc., about 50 feet; and above these lie the Upper Coal measures of this part of Ayrshire. The two beds of limestone, which are much altered by their contact with the volcanic rocks, appear to be unfossiliferous, but otherwise they are of similar character to the beds at Linn Spout. If they are not a continuation of those beds the Linn limestones have no place on the Ardrossan and Saltcoats shore.

Returning to the sections opened at Linn Spout, Glencart, Dalry, and Monkcastle Glen, Kilwinning, where the upper beds are well exposed, being worked in the two former places, they are found to be of the same physical character as the Lower Linn beds, but are richer in organic remains. From their nodular character, these limestones disintegrate very rapidly, and in the glen at Linn Spout from this cause they have a broken and shivery appearance.

The men in charge of the pits around Dalry hold an opinion that the shales between the upper and lower Linn series of beds run off, and that the two run into one bed, as two beds of coal sometimes do. This idea, however, is unworthy of notice, but I refer to it as the officers of the Geological Survey have adopted it, in paragraph 28 of the Explanation to sheet 22 of the Ayrshire Survey. It is quite true that to the east of Dalry the lower series of beds run off, only one bed being found, but this is the upper series of beds alone, as may be seen from the following fact. In the Linn and Langland pits, and at Linn Spout, on the bottom of the upper series, is a band of hard sandstone full of shell remains. At Bourtrapping and at East Bankend, where only a part of one bed is on, it is still found attached to the bottom of the beds. Now, if the two series of beds had run together, this band would have

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been found at the junction of the beds, just resting upon the top of the lower bed; but this is not the case. I think therefore that there is sufficient proof that the two series do not run together as the Survey officers suppose.

As already mentioned, the upper series of beds, wherever exposed in the neighbourhood of Dalry, are rich in fossils, but, as in the Lower Linn beds, they are mostly confined to the nodules of purer limestone, few being found apart from them. At Linn the nodules are very hard, and the shell remains are much crushed; at Bourtrapping they are not so much crushed, and good cabinet specimens are more easily procured.

The more common fossils, both at Linn Spout and Bourtrapping, are as follows. Corals, and broken stems and arms of Crinoids are found, though not abundantly, and in some of the beds appear to be absent. Polyzoa are got in some of the beds, though not well preserved. In a few feet of the beds, on a horizon about 6 feet from the bottom, remains of the Trilobite, *Phillipsia Eichwaldia*, Fischer, are abundant; but in the other part of the beds they are all but absent. The Brachiopoda are abundant, the more plentiful being *Athyris ambigua*, Sow., *Orthis resupinata*, Mart.; *Productus cora*, D'Orbigny; *P. longispinus*, Sow.; with the variety *lobatus*, Sow.; *P. latissimus*, J. de C. Sow., *P. punctatus*, Mart.; *P. scabriculus*, Mart.; *P. semireticulatus*, Mart., and the variety *P. concinus*, Sow.; *Rhynchonella pugnus*, Mart.; *Rhyncopora Youngii*, Dav. (this little shell is rather rare, and is generally found in small nests both at Linn Spout and Bourtrapping); *Spirifera trigonalis*, Mart.; *Martinia glabra*, Mart.; *M. Urei*, Flem.; *Reticularia lineata*, Mart.; *Dielasma hastata*, Sow., with its varieties, *sacculus*, Mart., and *vesicularis*, de Kon.; *Streptorhynchus crenistria*, Phill. The Lamellibranchs are rather rare in the beds, but a specimen is occasionally met with, as *Aviculopecten interstitialis*, Phill.; *A. orbicularis*, M'Coy; *Nucula gibbosa*, Flem.; besides a few others given in the list appended to this paper.

Few Gasteropods are found by hammering in these beds, although by careful manipulation some may be got. The greater number named in the following list were found by washing the *debris* obtained in cavities in the limestone formed by the dissolution of the purer carbonate of lime in the nodules through the infiltration of water containing carbonic acid. The Cephalopods are also badly represented. In a bed near the top of the series, at

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Linn Spout, a number of *Orthoceras* are found, but too sorely crushed for certain identification, and in the hard sandstone band at the bottom of the series, *Nautilus nodiferus*, Armst., is found, as well as a few fragments of others. Fish remains have also been got, as the teeth of *Petalodus Hastingsiæ*, Owen; *Tomodus convexus*, Ag.; a few fragments of *Helodus didymus*, Ag., and one specimen of *Helodus planus*, Ag. They all appear to be rare, but the probability is that, with the opportunities afforded by more extensive working, these Upper Limestone series of beds would yield to the collector as rich a harvest of fish remains as the beds of the Lower Limestone series have done.

In conclusion, I have once more the greatest pleasure in thanking my friend Mr. John Young, F.G.S., of the Hunterian Museum, Glasgow, for the kind assistance he has afforded me in the identification of fossils, and in the correction of the nomenclature—a kindness of which I have experienced the benefit for now a quarter of a century. Without the help of his extensive palæontological knowledge, the lists of fossils appended to this and to previous papers of mine on the Carboniferous strata of the Beith and Dalry districts could not have had the scientific value which I hope they possess; and I therefore take this opportunity of acknowledging the help I have received from him, and which has alway been given with a readiness as hearty as it is valuable.

For the list of fossils see the following page.

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LIST OF FOSSILS IN THE UPPER LIMESTONES OF NORTH AYRSHIRE.

	Highfield Limestone.			Lower Linn Limestone and Shale.	Shale below Upper Linn Limestone.	Upper Linn Limestone.		
	Swindridge.	Goldcraig.	Girthill.			Bourtrapping.	Glencart.	Linn Spout.
Actinozoa.								
Chætetes (Alveolites) septosa, Flem.								x
Cyclophyllum fungites, D. and T.						x	x	x
Fistulipora incrustans, Phill.				x				x
Heterotrypa tumida, var. *miliaria*, Nich.	x			x				x
Lonsdalia floriformis, Mart.							x	x
,, *rugosa* (?), M'Coy.						x		x
Zaphrentis patula, Mich.	x	x		x	x			x
Echinodermata.								
Archæocidaris Urei, Flem.	x		x					
Actinocrinus, sp. (?).	x	x						
Poteriocrinus crassus, Miller.	x		x		x			x
Cyathocrinus ellipticus, Phill.			x					
Pisocrinus globularis, de Kon.			x		x			
Annelida.								
Serpulites membranaceus, M'Coy.						x		x
Crustacea (Ostracoda).								
Bairdia plebeia, Jones and Kirby.	x							
Cytherella concinna, J., K., and B.	x							
,, *obliquata*, G. S. Brady.	x							
Leperditia Okeni, Munster.	x							
Kirkbya (Beyrichia) radiata, J. & K.	x							
,, *Eichwaldiana*, J. and K.	x							
Crustacea (Trilobita).								
Phillipsia Eichwaldi, Fischer.						x	x	x
,, ,, var. *mucronata*, M'Coy.	x							
Crustacea (Phyllopoda).								
Estheria (?) *punctatella*, Jones.					x			
Polyzoa.								
Fenestella tuberculo-carinata, Ether. jun.								x
Glauconome elegans, Y. and Y.								x

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	Highfield Limestone.			Upper Linn Limestone.				
	Swindridge.	Goldernig.	Girthill.	Lower Linn Limestone and Shale.	Shale below Upper Linn Limestone.	Bourtrapping.	Glencart.	Linn Spout.
Brachiopoda.								
Athyris ambigua, Sow.	x	x	x	x	x	x	x	
,, *Royssii* (?), Lév.				x	x		x	x
Chonetes Laguessiana, de Kon.	x				x			x
Discina nitida, Phill.								x
Orthis Michelini, Lév.				x	x			
,, *resupinata*, Mart.	x	x	x	x	x	x	x	x
Productus cora, D'Orb.								x
,, *giganteus*, Mart.		x						
,, *longispinus*, Sow. (var.)	x				x	x	x	x
,, *latissimus*, J. de C. Sow.	x	x	x	x	x	x	x	x
,, *mesolobus* (?), Phill.								x
,, *scabriculus*, Mart.		x		x	x	x		x
,, *semireticulatus*, Mart.	x	x		x		x	x	x
,, *sinuatus*, de Kon.						x		x
,, *Youngianus*, Dav.				x				
Rhynchonella pugnus, Phill.	x	x	x		x	x	x	x
Rhynchopora Youngi, Dav.						x		x
Spirifera trigonalis, Mart.	x	x	x	x	x	x	x	x
Martinia (*Spirifera*) *glabra*, Mart.						x		x
,, ,, *Urei*, Flem.					x	x		x
Reticularia (*Spirifera*) *lineata*, Mart.						x	x	x
Streptorhynchus crenistria, Phill.	x	x	x	x	x	x	x	x
,, ,, var. *radialis*, Phill.	x							
,, ,, var. *senilis*, Phill.						x		x
Strophomena rhomboidalis, Wahl.								x
,, var. *analoga*, Phill.								x
,, var. *distorta*, J. de C. Sow.						x		
Dielasma (*Terebratula*) *hastata*, Sow.						x		x
,, ,, *sacculus*, Mart.						x		x
,, ,, *Gillingensis*, Dav.						x		x
,, ,, *vesicularis*, de Kon.						x		x
Lamellibranchiata (Monomyaria).								
Anomia antiqua, Sow.					x			x
Avicula concinna, M'Coy.					x			
,, *decussata*, M'Coy.					x			
,, *lævigata*, M'Coy.				x				
Aviculopecten cælatus, M'Coy.					x			
,, *concentricostriatus*, M'Coy.					x			x
,, *consimilis*, M'Coy.						x		x
,, *interstitialis*, Phill.					x			
,, *ovatus*, M'Coy.							x	
,, *duplicicosta*, M'Coy.								x
Entolium (*Pecten*) *Sowerbii*, M'Coy.					x			
Posidonomya corrugata, Ether.				x				
Pteronites regularis, Ether.					x			

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	Highfield Limestone.			Lower Linn Limestone and Shale.	Shale below Upper Linn Limestone.	Upper Linn Limestone.		
	Swindridge.	Goldcraig.	Girthill.			Bourtrapping.	Glencart.	Linn Spout.
Lamellibranchiata (Dimyaria).								
Arca arguta, de Kon.					x			x
Schizodus (*Axinus*) *carbonarius*, Portl.					x			
,, ,, *deltoideus*, Phill.					x			
Cardiomorpha oblonga, Sow.					x			
Conocardium armatum, Phill.								x
Cypricardia striato-lamellosa, de Kon.					x			
Edmondia oblonga, M'Coy.			x		x			
Nuculina (*Leda*) *oblonga*, M'Coy.					x			
,, ,, *attenuata*, Flem.	x		x		x			
Leptodomus costellatus, M'Coy.	x				x			
Nucula gibbosa, Flem.	x	x	x		x	x	x	x
,, *acuta*, Sow.					x			
,, *lineata*, Phill.							x	
Modiola elongata (?), Phill.	x				x			
,, *divisa*, M'Coy.					x			
Allorisma (*Myacites*) *sulcata*, Flem.	x		x		x			
Sanguinolites subcarinatus, M'Coy.				x				
Ungalina, sp. (?).							x	
Venus (?), sp. (?).							x	
Gasteropoda.								
Capulus (*Platycerus*) *vetusta*, Sow.							x	
Entalis (*Dentalium*) *priscum*, Goldf.	x		x		x		x	
,, ,, *Dalryense*, J. Young.	x							
,, ,, *inornatum*, M'Coy.	x				x		x	
,, ,, *Scoticum*, J. Young.	x							
Euomphalus acutus, Sow.								x
,, *serpula*, de Kon.							x	
Schizostoma (*Euomphalus*) *carbonarius*, Sow.	x		x		x		x	
Loxonema Lefebvrei, Lév.								x
,, *rugifera*, Phill.						x	x	
,, *scalaroidea*, Phill.	x							
,, *brevis*, M'Coy.			x		x			
Macrochilina (*Macrocheilus*) *imbricatus*, Sow.	x						x	
,, ,, *acutus*, Sow.	x				x		x	
Polyphemopsis (*Macrocheilus*) *fusiformis*, Sow.	x						x	
Natiria (*Naticopsis*) *lirata*, Phill.							x	
Naticopsis plicistria, Phill.					x			
,, *variata*, Phill.	x		x		x		x	
,, *canaliculata*, M'Coy.								x
Tychonia (*Naticopsis*) *Omaliana*, de Kon.	x							
Aclisina (*Murchisonia*) *striatula*, de Kon.	x		x				x	
Pleurotomaria altavittata, M'Coy.					x			

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	Highfield Limestone.			Lower Linn Limestone and Shale.	Shale below Upper Linn Limestone.	Upper Linn Limestone.		
	Swindridge.	Goldcraig.	Girthill.			Bourtrapping.	Glencart.	Linn Spout.
Gasteropoda—*Continued.*								
Agnesia (*Pleurotomaria*) *acuta*, Phill.							x	
,, ,, *contraria*, de Kon.			x					
Ptychomphalus (*Pleurotomaria*) *monilifera*, Phill.	x		x		x			
,, ,, *Frenoyana*, de Kon.							x	
Baylea (*Pleurotomaria*) *Yvanii*, Lév.							x	
Mourlonia ,, *granulata*, de Kon.							x	
,, ,, *interstrialis*, Phill.							x	
Strobæus (*Elenchus*) *antiquus*, M'Coy.							x	
,, ,, *subulatus*, M'Coy.							x	
Turbonitella (*Turbo*) *biserialis*, Phill.							x	
Microdoma (*Trochus*) *biserratus*, Phill.	x							
Niso Smithiana, J. Young, sp. nov.							x	
Polyphemopsis (*Eulima*) *Phillipsiana*, de Kon.	x							
Heteropoda.								
Bucania (*Bellerophon*) *cornu-arietis*, Sow.		x						x
,, ,, *decussata*, Flem.	x		x	x	x			
Waagenella ,, *Dumontii*, D'Orb.								x
Euphemus ,, *Urei*, Flem.	x		x	x	x			
Porcellia puzo, Lév.							x	x
Cephalopoda.								
Orthoceras attenuatum, Flem.		x			x		x	x
,, *cinctum*, Sow.			x		x		x	x
,, *undatum*, Flem.					x			
,, sp. (?).							x	
,, *cylindraceum*, Flem.		x	x					
Cyrtoceras Gesneri, Mart. (fragment).							x	
Goniatites striatus, Sow.	x		x					
Nautilus nodiferus, Armst.						x	x	x
,, *quadrata*, Flem.		x						x
,, sp. (?).								x
Pisces.								
Tomodus convexus, Ag. (Syn. *Cochliodus magnus*, Ag.)	x	x						x
Deltodus, sp. (?).	x							
Helodus didymus, Ag.		x	x					x
,, *lævissimus*, Ag.		x				x		x
Acrolepis Rankinei, Ag.	x							
Petalodus Hastingiæ, Owen.	x	x				x	x	x
Pœcilodus, sp. (?).							x	
Cladodus mirabilis, Ag.								x

Note.—I am indebted for the greatest number of the *Gasteropoda* found in the Glencart column to the list by Mr. John Young, F.G.S., in "Notes on the Fossils found in a thin bed of impure limestone at Glencart, near Dalry, Ayrshire." *Proc. Nat. Hist. Soc. Glasgow*, Vol., V. p. 234 (1883).

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No. III.—The Parallel Roads of Lochaber; the Problem, its Conditions and Solutions. By William Jolly, F.R.S.E., F.G.S., *V.P.*

[Read 14th May, 1885.]

[Summary.]

The author thought the subject of perennial interest to all geologists, on account of both its intrinsic importance and the eminent men who had written of it. The true solution could not yet be said to have been *finally established*, and elaborate papers were still appearing at intervals, advocating rival theories. His aim was to state the problem, explain the solutions offered, give its bibliography, criticise the theories, and develop more fully the one he adopted. He first described the locality of the Roads in Glen Roy, Glen Spean, Glen Gluoy, and Glen Laggan, all at the south end of the Great Glen. Their unique and striking aspect was such as to draw the attention of the primitive Celts. They had received several names. They were known in Gaelic as *Na Casan*, literally The Feet, hence Footpaths, of which the English *Roads* was a literal translation. Campbell of Islay's rendering, "The Bends," the late Rev. Mr. McGregor, the Gaelic scholar, of Inverness, thought fanciful, and without foundation. They were also variously called "roads," "lines," "shelves," "parallels," etc. The highest of those recognized is in Glen Gluoy, at 1,172 feet, another existing there at 964; the three chief in Glen Roy stand at 1,148, 1,067, and 855; the lowest sweeping round into Glen Spean at the same level. A possible Road, discovered by Darwin in 1838, in Glen Laggan, above the Loch Laggan Locks, is 1,300 feet high. Their breadth varies from 40 to 70 feet, giving an average of 60. They slope towards the valley at an angle of from 5 deg. to 30 deg., the hill face being inclined from 25 deg. to 40 deg.

By means of a printed diagram, which enhanced the clearness of the exposition, Mr. Jolly then explained the Conditions of the Problem, all of which must be satisfied by any theory claiming to be the true solution, as follow:—

A.—The Conditions of the Problem.

I.—*The Peculiar Form and Character of the Roads.*

1. Their general horizontality and parallelism.
2. Their general equality of width, (*a*) in the course of the same line, and (*b*) in relation to each other.

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3. Their general continuity.

4. Their stair-like form, as of parallel layers laid successively on each other on the hill side; the highest being closest to the hill: as originally pointed out and sketched by Macculloch.

5. Their sloping towards the valley.

6. Their being proportionately narrower where they are steeper.

7. Their general absence where solid rock protrudes, and where the slope is exceptionally flat.

8. The *debris* of the hill, above and below the Roads, sloping more or less at the angle of repose.

II.—*Their Composition.*

9. The absence of rounded, water-worn stones along them; and the general greater or less angularity of those found.

10. Their consisting of the same *débris* as the rest of the hill-face, and not of transported matter.

11. The absence of cliffs, caves, or rock-notching, or any deep erosion, along their course—with rare exceptions.

III.—*Their Distribution.*

12. Their sudden endings in all cases, without greater accumulations of *débris*, or other indications of the cause of the same.

13. The symmetrical disappearance of the same lines at points opposite each other, in the same and contiguous valleys.

14. The outward extension of the Roads, in the same and contiguous valleys, according to their lesser altitude.

15. Their occasional disappearance for considerable distances.

16. Their different altitudes in different glens; and the absence of the same lines in neighbouring glens.

17. Their being confined to Glen Roy and neighbourhood.

IV.—*Their Relations.*

18. The existence of cols in connection with, and slightly lower than, each of the four main Roads.

19. The existence of other lines of a different character, above and below the Roads. (Dwelt much on by Chambers.)

20. The existence of much terraced *débris*, below the Roads, in the bottoms of the valleys containing them.

21. The relation of the Roads to the marked glaciation of the district and its abundant remains.

B.—The Bibliography of the Problem.

Mr. Jolly then expounded, by means of another diagram, the various Theories proposed to satisfy these Conditions, and account for the Roads; naming the writers advocating them, and the various works which they had written, with their dates. All these are given here in the following table:—

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	THEORIES.	WRITERS.		WORKS.
By man—Human.	Fingal	Old inhabitants.		
	Hunting roads of kings ...	Old inhabitants.		
		Pennant	1769	Pennant's "Tour," 1771.
	Aqueducts for irrigation ...	Playfair	1816	Proc. Roy. Soc. Edin., 1816.
By a flood—Diluvial	... ...	Sir Geo. S. Mackenzie	1848	Edin. Phil. Journal, Jan. 1848.
		Prof. Rogers	1861	Lect., Roy. Inst. London, March, 1861.
By the sea—Marine.	... ...	Darwin	1839	London Phil. Trans., 1839.
		Lyell (visited 1825) ...	1841	"Elements of Geology."
		Chambers	1848	"Ancient Sea Margins."
		Rev. R. Boog Watson	1866	Quar. Jour. Geol. Society, February, 1866.
		Prof. Nicol	1869	Quar. Jour. Geol. Society, August, 1869.
		Campbell of Islay ...	1877	"Parallel Roads of Glen Roy," (privately printed.)
		Macfadzean	1882	"Parallel Roads of Glen Roy." (Menzies, Edin.)
By a lake—Lacustrine.	Nature of dam not stated ...	Macculloch	1817	Trans. Geol. Soc. Lond., 1st series, vol. iv.
		Bryce,...	1850	Proceedings of Phil. Soc. Glasgow.
		Lubbock	1868	Quar. Jour. Geol. Society, May, 1868.
		Babbage	1868	Quar. Jour. Geol. Society, August, 1868.
		Dakyns	1879	Geol. Mag., Dec., 1879.
	Dam of *débris*—detrital dam.	Dick-Lauder	1823	Trans. Roy. Soc. Edin., vol. ix.
		Milne Home	1847	Proc. Roy. Soc. Edin., 1847.
		Do.	1876	Trans. Roy. Soc. Edin., vol. xxvii., 1876.
		Do.	1877	Trans. Roy. Soc. Edin., vol. xxviii., part i., 1877.
	Dam of ice—glacial dam.	Agassiz (visited 1840)	1842	Quar. Jour. Geol. Society, vol. iii., 1842; "Atlantic Monthly," June, 1864. (Both by Agassiz.)
		Buckland (do.)	1842	
		James Thomson ...	1848	Edin. New Phil. Jour., vol. xlv.
		Jamieson	1863	Quar. Jour. Geol. Society, vol. xix., January, 1863.
		Darwin	1863	In private letters, etc.
		Lyell	1863	"Antiquity of Man."
		Archibald Geikie ...	1865	"Scenery and Geology of Scotland."
		Jolly	1873	Trans. Geol. Soc. Edin., April, 1873; also in Milne Home's paper, Trans. Roy. Soc. Edin., 1876.
		James Geikie	1873	"The Great Ice Age."
		Sir Henry James ...	1874	"Parallel Roads of Lochaber," Ord. Survey Office.
		Rev. T. Brown... ...	1876	Proc. Roy. Soc. Edin., vol. viii., March, 1876.
		Tyndal	1876	Roy. Inst., June, 1876; "Pop. Science Review," October, 1876.
		Colin Livingston ...	1878	Trans. of Inverness Field Club, vol. i. p. 101.
		Prestwich	1879	Roy. Soc. London; *Nature*, May 29, 1879, in abstract; Lond. Phil. Trans., 1880, in full.
		Jolly	1880	*Nature*, May 20, 1880; Trans. of Inverness Field Club vol. i. p. 287.

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C.—The Solutions of the Problem.

I. After referring to the Traditional theories of Fingal and the Hunting Roads, adopted by Pennant, in his remarkable "Tour," published in 1771, Mr. Jolly told how Playfair had seen similar appearances exhibited by irrigation works at Brieg, in the Valais, which suggested to him his curious solution.

II. The Diluvial theory held that the Roads were caused by an immense flood from the Atlantic, through a sinking of the West Coast, rushing impetuously up these valleys. There was no use seriously criticising this theory, though adopted in 1861 by Prof. Rogers of Glasgow; the theory being suggested to him by his thinking that the Roads were higher at the upper ends of the glens than at the lower, which had been found not to be the case.

III. The Marine theory had had many able supporters, from its first suggestion by Darwin in 1839, to Campbell of Islay in 1877, and Mr. Macfadzean, of the Inland Revenue, in Glasgow, who had published a large and learned volume (Edinburgh, Menzies) so recently as 1882. The greatest exponent of this theory was Robert Chambers, in his "Ancient Sea Margins" published in 1848, who held that these lines were nothing but sea beaches, similar to those found so plentifully all over the country. He contended that other lines in these same glens were of the same kind; but these had been shown by Mr. Jolly, in 1873, to be entirely different in character, outline, and composition, and were probably moraines; (*Trans. Geol. Soc. Edin.*, 1873.)

Mr. Jolly then traversed the conditions of the Problem laid down above, and showed how this theory violated, or failed satisfactorily to account for, Nos. 1, 4, 5, 7, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, and 21; by each of which it may be tested.

IV. The Lacustrine theory would not be found open to the same objections. The great difficulty here was the nature of the dam, or barrier, that confined the waters of the lakes, of which the famous Roads were the successive shores or beaches. This theory was propounded in 1817 by the far-seeing Macculloch, the eminent geologist and early delineator of Highland scenery and geology; but he, along with others, had not condescended on the kind of barrier required.

Two styles of dam had been contended for by different writers, the one of detritus, the other of ice. The Detrital dam, first suggested by Dick Lauder in 1823, had been adopted by Milne Home, who

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accompanied Robert Chambers to the region in 1847. He had written of it then, and twice since, with an amount of observation and detail that was of great and permanent value. These writers held that the lakes were contained by huge banks of *debris*, deposited by the sea and other causes, similar to those existing abundantly in many parts of the country. There was no doubt whatever that a large number of lakes, past and present, had been dammed back by such barriers in many places. But if the Roads were so formed, why were not such remarkable lines (whose character was unique) found elsewhere? Mr. Jolly here examined this theory in detail, in connection with the requisite Conditions, and held that it failed to satisfy many of them. How were these barriers so conveniently deposited at the required points, when the Great Glen, and the other valleys, were, according to Milne Home, filled with similar detritus? In the other lakes adduced by him, the outlets were *over the debris*, gradually wearing it away, while here the outlets existed at the upper ends, flowing over hard rock. The Roads ended abruptly on the hill face, with no remains of the asserted barriers heaped up *at their extremities*, as might be expected, and as was almost universal. How were the requisite great accumulations so effectively removed, reaching, as these must have done, to above 1,300 feet? The successive roads were on the same hill-face, so that the damming *debris* must have been wholly removed between the lines at their lower ends, before the new beaches were laid down. Mr. Jolly entered into other difficulties attending this theory, and finally concluded against it.

D.—The Glacial Theory, as adopted by the Author.

The Glacial theory was started by Agassiz, the great Swiss, who had been accustomed to see the work of glaciers, after a visit paid to Lochaber in company with Buckland, in 1840. It has had the greatest number of adherents, Darwin and Lyell having also given up the Marine theory for it. Its chief exponent was Jamieson of Ellon, in an admirable paper published in 1863. By means of a Survey map, Mr. Jolly entered into a careful explanation of the glaciation of the region. He held that the Roads were produced by lakes dammed back by glacial ice, filling the lower parts of the valleys up to the ends of the Roads, and gradually retreating with the ameliorating climate, *at the last stage of the second portion* of the Glacial epoch, immediately before the final disappearance of

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local glaciers from Scotland. The abundant rolled *debris* at the bottom of these valleys was laid down by former glaciers, and re-sorted by the sea during the great depression in the *middle* of the Glacial period.

Mr. Jolly entered into a detailed description of the peculiar configuration of the Ben Nevis Range, with its parallel system of valleys opening out, on the south, to the close, deep Glen Nevis and its eastern continuation, and, on the north, to the broad Glen Spean, and broader Glen More. The peculiarity of Glen Spean was that it would receive not only the abundant ice from the glens opening directly on it on the south, but also the greater part of the ice accumulated in Glen Nevis and its continuation, by the two outlets of Loch Treig and Glen Nevis itself. By this means, and by its special relation to the highest mountains in Scotland, it would receive an unusual supply of ice, equalled by no other valley in the country. This was proved not only by its geographical conformation, but by the superabundant glacial remains in the district, of which Mr. Jolly gave full details.

During the first period of greater glaciation in the Glacial period, the ice from Loch Treig, after entering Glen Spean, turned both eastwards down Loch Laggan, and westwards down the Spean. Glen Roy itself was filled with an overflow ice-stream from the same valley, which *moved out at its head down the Spey*, as shown convincingly by the ice-markings there; and the Great Glen and its side valleys were also swathed in ice. As the climate improved at the *final close* of the Ice period, the glaciers gradually shrank backwards to their sources in the high Nevis glens. From their altitude, and neighbourhood to the vapour-feeding Atlantic, these would be the last in the country to preserve local glaciers. Through its peculiar relations to these glens, Glen Spean would, at that time, be filled from its head to the sea with a great ice-stream, resting on the *debris* already deposited by the sea, etc., and moving slowly downwards. This stream, entering the south end of Glen Roy, dammed back a lake there, fed by its tributary torrents, which has left its traces in the Roads. As the ice gradually shrank in successive steps, the water subsided and the lake extended, as shown by these lines.

Mr. Jolly here pointed out on the map the position of the successive contractions of the ice required to dam the lake, and described the abundant evidences of this last stage of the glaciers

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there, in scratchings, carried blocks, boulder clay, etc., and in the splendid horse-shoe moraines of the Treig glacier, lying intact across and along Glen Spean. He held that the lowest Road extended up Loch Treig only a short distance, suddenly ceasing there—and not round the whole lake, as asked by Milne Home and Dick Lauder —an additional remarkable proof in favour of a glacier then filling that basin down to the ends of the Roads, where a dam was necessary.

Similar explanations were given regarding the Glen Gluoy Parallels. The ancient lake in Glen Gluoy was dammed back by a great accumulation of ice then filling the Great Glen, in the bed of the present Loch Lochy. At the mouth of Glen Gluoy, there then existed an immense congestion of ice, caused by the meeting of the ice of the Great Glen itself and that of Loch Arkaig valley, which was filled with a deep ice stream, as proved by its abundant scratches. Part of this congested ice was forced right up Glen Gluoy, during the greater portion of the Glacial period, and went out at its head into Glen Roy, and so along with the Glen Roy ice, down Glen Spey. At the close of the Glacial epoch, the Glen Gluoy ice shrunk down from the head of its glen ; but, remaining stationary for a period, dammed back a lake there at the points where the Roads terminate, and then, like the rest of the ice, vanished with the ameliorating climate that finally obliterated all glaciers from Scotland.

Mr. Jolly had studied the subject for more than fourteen years during his residence in the north, his professional work as Inspector of Schools in the very district giving him unwonted opportunities for examining the phenomena at all points. He hoped shortly to embody his observations and conclusions in two papers—one on the glaciation of the Nevis Mountains, which he had worked out, and the other on the application of the results of this paper to the Glen Roy problem. He had also had the pleasure of traversing the ground carefully with Dr. Milne Home, an excellent mountaineer and painstaking observer. A joint letter of theirs, sent to Sir Henry James, had happily been acted on in an enlightened way, by securing the return to the district of efficient Survey officers to map the whole phenomena, especially important points suggested by them, with a fulness and accuracy greater than usual ; which was a permanent gain to all students of the difficult and much-debated question.

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Mr. Jolly concluded with an appeal to the members of the Society to study the fascinating problem on the ground itself.

By means of coloured additions laid over the map, the state of the ice during its successive contractions and stationary positions, at the end of the Glacial epoch, as necessary to fulfil the requisite conditions, was graphically exhibited.

The reader may consult with advantage, for the better understanding of the subject, the admirable maps of the district by the Ordnance Survey, both the six-inch and one-inch, in which the Roads and the related phenomena are accurately and fully laid down; also the special Ordnance selected map of the locality, appended to the paper of Sir Henry James, mentioned above.

No. IV.—Notes on some Fossil Plants collected by Mr. R. Dunlop, Airdrie, from the Lanarkshire Coal-field. By Robert Kidston, F.G.S. With a Plate [No. III.]

[Read April 2nd, 1885, with additions made May, 1886.]

Through the kindness of Mr. Dunlop I have had the opportunity of examining the fossil plants collected by him from several localities in the Lanarkshire Coal-field. The annexed list of species compiled from this collection, though of considerable interest, must not be regarded as a complete representation of the Carboniferous fossil flora of this district; but it contains one or two species which have not been previously recorded from Scotland. I have only to express my hope that Mr. Dunlop will continue his investigations in a field of natural history on which he has so successfully entered. Many of the specimens he has secured are exceedingly fine; of some of the species, they are finer than any I have yet seen from the British Coal-fields.

As it is my intention to work out the distribution of the Carboniferous flora, I am much indebted to Mr. Dunlop for the facilities he has given me in examining his specimens. I shall be very glad if others, who possess specimens of Carboniferous fossil plants, would kindly allow me to examine them, and so assist in working out their distribution; on my part I shall be most happy, as far as I can, to help any who may wish for assistance in the study of this most interesting class of fossils.

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It is only possible, by mutual co-operation, to compile a complete list of the Carboniferous fossil plants from an area so large and rich as that of the British Coal-fields.

Calamariæ.

Calamites, Suckow.

Weiss, in his two volumes on *Calamites*,* has contributed so much to our knowledge of the stems and their ramification, the fructification, foliage, and roots of *Calamites*, that this group of fossil plants can no longer be looked upon as that about which we are most ignorant. His first volume deals chiefly with the fructification of *Calamites*, his second treats of the stems, as well as of the foliage and roots, with much additional information in regard to their fructification and systematic position.

The Calamariæ have usually been classed with the Equisetaceæ; but from the examination of their fructification it is seen that there are points in which they clearly differ from the recent *Equisetum*. On the other hand, there are some characters in which *Calamites* have a considerable similarity with the Equisetaceæ, and among recent plants it is certainly with this group they have the greatest affinity.

It would appear that *some* of the fossil cones which have been referred to the Calamariæ show that their upper part bore *microspores*, whilst their lower portion bore *macrospores*, nor are the spores provided with *elaters*, as in *Equisetum*.† But in the order Lycopodiaceæ some members are *heterosporous* and others *isosporous*. For example, *Lycopodium* has only one kind of spore (*isosporous*), while *Selaginella* has both *microspores* and *macrospores* (*heterosporous*). It may, perhaps, be found then that, although some of the cones which are supposed to belong to *Calamites* show a *heterosporous* condition, this may not be of sufficient importance to exclude them from the Equisetaceæ, where the spores are *isosporous*. It is also most probable that the genus *Calamites*, when its fructification is more fully examined, will require to be

* "Steinkohlen-Calamarien. — Part I., Abhandl. zur geologischen Specialkarte von Preussen und den Thüringischen Staaten, band ii., heft i., 1876; "Steinkohlen-Calamarien.—part II.," Abhandl. &c., band v., heft ii., 1884.

† See also Dr. Williamson's papers on the structure of *Calamites* published at various dates in the *Philosophical Transactions*.

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separated into many genera; and in this light the genus *Calamites*, as Weiss points out, can only be regarded as of a most provisional nature.

The roots of *Calamites* are those fossils to which Lindley and Hutton applied the name of *Pinnularia*.

From our present standpoint of knowledge, Weiss proposes to divide the genus *Calamites* into the four following groups:—

CALAMITES, Suckow (provisional genus).

Division A. *Furrows on stems alternating at the nodes or joints.*

Group I. *CALAMITINA*, Weiss.

Branch-scars occurring periodically, the nodes bearing scars being separated from each other by a certain number of joints which do not bear branches. In most cases there is a regular increase or decrease in the length of the joints which connect the branch-bearing nodes.

Group II. *EUCALAMITES*, Weiss.

Branch-scars occurring on every joint. The joints are of the same length or of irregularly different lengths.

Group III. *STYLOCALAMITES*, Weiss.

Branch-scars occurring without definite order, subordinate; often long stretches of the stem occur on which the branch-scars are entirely absent. The joints are of equal length or irregularly different.

Division B. *Furrows on the stem not alternating at the nodes or joints.*

Group IV. *ARCHÆOCALAMITES*, Stur (*Asterocalamites*, Schimper; *Calamites*, Brongniart).*

Branch-scars irregularly distributed. Joints unequal in length.

For the purpose of classifying these fossils, the groups proposed by Weiss will be found most useful; but perhaps Nos. I., II., and III. had better be regarded at present as convenient *sections* rather than *genera*. Group IV., on the other hand, is so well

* The fruit of *Archæocalamites* is the *Pothocites Grantonii* of Paterson. See *Ann. & Mag. Nat. Hist.* May 1883, p. 297.

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defined, both as concerns its stems and fruit, that it must be regarded as a true *genus* and quite distinct from *Calamites*.

In geological distribution groups I.–III. are characteristic of the Coal-measures; group IV. of the Lower Carboniferous (= Carboniferous Limestone series and Calciferous Sandstone series).

A good deal of discussion has taken place as to whether the exterior surface of the bark of *Calamites* was smooth or furrowed. It appears, as is often the case in such differences of opinion, that both views are correct in part. It now seems clearly proved that the species with thin bark show on their outer surface the characteristic furrows, but, on the other hand, the stems with thick bark show no trace of the furrows on their outer surface. The decorticated stems, however, are always distinctly furrowed, and it is in this condition that *Calamites* most frequently occur. This vexed question, from the careful investigations of Prof. Weiss, seems to be now satisfactorily settled.

Group I. *Calamitina*, Weiss.

Calamites (*Calamitina*) *varians*, Sternberg.

Calamites varians, Sternberg, Vers. ii., p. 50, pl. xii.

Remarks. This specimen belongs to one of the forms of this species, but is not in a good state of preservation.

Locality. Drumgray Coal, Airdrie.

Calamites (*Calamitina*), sp.

Remarks. Unfortunately only a few fragmentary specimens of these plants were collected. They belong to the group of *Calamites* with a thick smooth bark. At the nodes the leaf-scars form a chain of transversely oval contiguous scars, similar to those occurring in *Calamites* (*Calamitina*) *varians*, var. *inconstans*, Weiss ("Steinkohlen-Calamarien," vol. ii. p. 69, pl. xxv.). From the fragmentary nature of the specimens, however, I cannot with any certainty refer them to that species. We can only hope that more perfect examples will soon be found which will enable us satisfactorily to determine the species.

Locality. Blaes between Kiltongue and Drumgray Coals; Whiterigg Colliery, near Airdrie.*

* As the plants from this bed occur in a state of great perfection, to show its exact position I append a section, which was procured for me by Mr. Dunlop from Mr. Prentice, manager of the colliery.

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Calamites Cistii, Brongniart.

Calamites Cistii, Brongniart, Hist. d. végét. foss., p. 129, pl. xx.

Locality. Pit near Calder Iron Works, Airdrie.

Group II. *Eucalamites*, Weiss.

Calamites (*Eucalamites*) *ramosus*, Artis.

Pl. III, fig. 1.

Calamites ramosus, Artis, Antedil. Phyt., pl. ii.

Calamites (*Eucalamites*) *ramosus*, Weiss, Steinkohlen-Calamarien, part ii., p. 98, pl. v., figs. 1, 2, pl. vi., pl. vii., figs. 1, 2, pl. viii., figs. 1, 2, and 4, pl. ix., figs. 1, 2, pl. x., fig. 1, pl. xx., figs. 1, 2.

Calamites nodosus, Lindley & Hutton, Foss. Flora, vol. i., pls. xv., xvi.

Annularia radiata, Zeiller, Végét. foss. du terr. houill. de la France, p. 24, pl. clx., fig. 1.

Asterophyllites radiatus, Brongniart, Class. d. végét. foss., p. 35, pl. ii., fig. 7.

Asterophyllites foliosus, Lindley & Hutton, Foss. Flora, vol. i., pl. xxv., fig. 1.

Annularia ramosa, Weiss, "Beobachtungen an Calamiten und Calamarien," *Neues Jahrb.*, vol. ii., 1881.

Section of Strata between the Kiltongue Coal and the Upper Drumgray Coal, showing the Fern-bed (*Stanrigg Colliery, by Airdrie*).

		Ft.	In.
Coal (including 3 inches of gas-coal),	Kiltongue	1	0
Dark fireclay,	Kiltongue	0	5
Coal,	Kiltongue	1	4
Fireclay,		0	10
Argillaceous schist,		5	6
Fireclay,		1	1
Coal,		0	6
Argillaceous schist,		4	10
Sandstone,		5	9
Argillaceous shale,		1	1
Coal,		0	8
Argillaceous shale,		3	6
Sandstone,		2	5
Argillaceous schist (*Fern-bed*),		2	6
Argillaceous shale,		3	3
Sandstone,		3	3
Argillaceous schist,		1	8
Shale (dark), studded with *Anthracosia*,		1	0
Argillaceous shale,		0	8
Sandstone (hard),		5	6
Argillaceous shale,		0	10
Coal (Upper Drumgray),		2	0

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Remarks. This species is very fully described by Weiss. The little branches, with verticillate leaves, each of which terminates in a sharp apex and is also tapered from its centre to its point of attachment with the stem, and which have been described as *Annularia radiata*, are now known to be the foliage of this plant. The fruit is also described by Weiss. This and the following species are the two most common *Calamites* in the Scotch Coal-measures.

Localities. Blaes between Kiltongue and Drumgray Coals, Whiterigg, near Airdrie; Pits, Airdrie; Shettleston, near Glasgow; Bent Colliery, about 1½ mile E. of Bothwell; Mount Vernon; Inkerman Pit, Airdrie; Calderbank, near Airdrie; Bellsdyke Pit, Airdrie.

Group III. *Stylocalamites*, Weiss.

Calamites (*Stylocalamites*) *Suckowii*, Brongniart.

Calamites Suckowii, Brongniart, Hist. d. végét. foss., p. 124, pl. xiv., fig. 6, pl. xv., figs. 1-6, pl. xvi., figs. 2, 3 (? fig. 1).

Calamites Suckowii, Zeiller, Végét. foss. du terr. houil. de la France, p. 12, pl. clix., fig. 1.

Calamites (*Stylocalamites*) *Suckowii*, Weiss, Steinkohlen-Calamarien, part ii., p. 129, pl. ii., fig. 1, pl. iii., figs. 2, 3, pl. iv., fig. 1, pl. xxvii., fig. 3.

Localities. Pits near Airdrie; Bent Colliery, about 1½ mile E. of Bothwell; Inkerman Pit, near Airdrie; Pit near Calder Iron Works, near Airdrie; Calderbank, near Airdrie.

Calamocladus, Schimper.

Calamocladus equisetiformis, Schlotheim, sp.

Calamocladus equisetiformis, Schimper, Traité d. paléont. végét., vol. i., p. 324, pl. xxii., figs. 1-3.

Asterophyllites equisetiformis, Brongniart, Prodrome, p. 159; Germar, Vers. v. Wettin u. Löbejun, p. 21, pl. viii.

Hippurites longifolia, Lindley & Hutton, Fossil Flora, vol. iii., pls. cxc., xci.

Casuarinites equisetiformis, Schlotheim, Flora d. Vorwelt, p. 30, pl. i., figs. 1, 2, pl. ii., fig. 3.

Remarks. A very fine specimen of this species has been collected. It shows the remains of four branches, the longest of which, however, is incomplete, but measures 8 inches and bears seventeen whorls of leaves. From the position in which the branches lie to each other they have evidently been attached to a common stem. Each whorl contains about thirty leaves.

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Localities. Bent Colliery, about 1½ mile E. of Bothwell; Blaes between Kiltongue and Drumgray Coals, Whiterigg, near Airdrie; Calderbank, near Airdrie.

Calamocladus grandis, Sternberg, sp.

Calamocladus grandis, Schimper, Traité d. paléont. végét., vol. i., p. 325.
Bechera grandis, Sternberg, Vers. i., fasc. iv., p. xxx., pl. xlix., fig. 1.

Remarks. Most probably this species is not distinct from *Calamocladus equisetiformis*, Schl. sp.

Locality. Bent Colliery, about 1½ mile E. of Bothwell.

ANNULARIA, Sternberg.

Annularia patens, Sauveur, sp.

Pl. III., fig. 2.

Asterophyllites patens, Sauveur, Végét. foss. du. terr. houil. de la Belgique, pl. lxix., fig. 4.

Description. Stem faintly striated longitudinally; internodes varying in length (according to the age of the specimen). Leaves whorled, numerous (8–16 in a whorl), long, linear, narrow, single-nerved, and terminating in a sharp point; basal portion of leaf not contracted. The leaves vary in length from $\frac{3}{10}$ of an inch on the smaller branches to nearly an inch on the larger, and in width from $\frac{1}{20}$ to $\frac{1}{25}$ of an inch. From the leaf-whorls are given off lateral branchlets.

Remarks. Of this species the only figure with which I am acquainted is that given by Sauveur, which only shows a portion of a whorl of leaves. Unfortunately no description accompanies his sketch.

The leaves are long in proportion to their breadth and of equal width throughout, and this, in connection with their not being contracted at their base, easily distinguishes *Annularia patens* from *Annularia radiata*. The leaves are generally rather longer than one and a half times the length of the internodes. On the smaller branches, of course, the leaves and internodes are smaller than on the larger branches, but they usually hold the same proportional relationship to each other in size. One small example shows a lateral branch springing from the axil of one of the leaves; but none of the other nodes of this example gives rise to branches. From this its mode of ramification appears to be irregular.

Although this species has not been previously recorded from Britain, I have seen it, in addition to the Airdrie locality, from the Coal-measures, Furnace Bank Pit, Old Sauchie, near Alloa,

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and Devonside, Tillicoultry, Clackmannanshire; and Blairpoint, Dysart, Fife.

Localities. Pit, near Airdrie; Calderbank; Bellsdyke Pit, near Airdrie.

PALÆOSTACHYA, Weiss.

Palæostachya gracillima, Weiss.

Pl. III., fig. 3.

Palæostachya gracillima, Weiss, Steinkohlen-Calamarien, part II., p. 184, pl. xviii., fig. 1. 1884.

Remarks. Several specimens of this cone have been collected at Calderbank, one of which is given at fig. 3. Almost none of the examples show the complete length; the largest of those figured, which however is imperfect, measures 2½ inches.

The sporangia are situated in the axils of the bracts, and in many cases the sporangiophores, to which the sporangia have been attached, are clearly exhibited. An enlarged view of a sporangium is given at fig. 3*a*, where are shown the *sporangium* (*a*), the *sporangiophore* (*b*), the *bract* (from the axil of which the sporangiophore springs) (*c*), and the axis of the cone (*d*).

The characters of the genus are very well illustrated in some of these specimens.

The necessity of collecting *all fragments* of fructifications cannot be too much emphasized, as often on apparently badly preserved specimens the arrangement of the sporangia is more clearly shown than on more perfect examples where the bracts remain in position.

Locality. In debris taken out of the foundation for the new Caledonian Railway Bridge, Calderbank, about two miles south of Airdrie.

CALAMOSTACHYS, Schimper.

(?) *Calamostachys longifolia*, Weiss.

Pl. III., fig. 4.

Calamostachys longifolia, Weiss, Steinkohlen-Calamarien, part I., p. 52, pl. x., figs. 2 and 3. 1876.

The cones placed here, though smaller, have all the characters of those figured by Weiss in his Steinkohlen-Calamarien, part I., pl. x, figs. 2 and 3, the peculiar character of which, Weiss thinks, results from a malformed growth, perhaps brought about by insects, but from whatever cause, he is inclined to regard the two specimens figured by him on his plate x., figs. 2 and 3, as monstrosities.

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The Calderbank specimens, especially that figured at 4*a*, show the verticillate arrangement of the leaf-scars similar to that occurring on Weiss' specimens, as also some of the very narrow leaves still attached. On our figure 4 the cones are seen to spring from *alternate* nodes of a calamitic stem and on the counterpart of this specimen, from the fortuitous manner in which a small part of the matrix lifted up, a third cone is seen to spring from the node of the middle group of cones. The position of this third cone is indicated at fig. 4 in dotted lines.

This example (fig. 4) has a great resemblance to *Volkmannia polystachya*, Sternberg (Vers. i., fasc. 4, p. xxx., pl. xli., fig. 1*a*). There the cones are developed in groups of four (as has probably been the case with our specimen), and some of the cones on Sternberg's plant also show the verticils of little tubercles, but the imperfect preservation of his example and the diagrammatic style of his figure do not afford very satisfactory grounds for comparison.

I have figured the Calderbank specimens with the object of bringing them before collectors in the hope that they may carefully preserve all such examples.

Locality. In debris taken out of the foundation for the new Caledonian Railway Bridge, Calderbank, about two miles south of Airdrie.

Calamitic Cones.

Several cones, probably referable to *Calamites* or *Sphenophyllum*, have also been collected, but their state of preservation does not admit of any satisfactory determination.

Localities. Calderbank, Inkerman, and Gartlee Pits, near Airdrie.

(?) RHIZOCARPEÆ.

SPHENOPHYLLUM, Brongniart.

Sphenophyllum cuneifolium, Sternberg, sp.

Sphenophyllum cuneifolium, Zeiller, Végét. foss. du. terr. houil. de la France, p. 30, pl. clxi., figs. 1, 2.

Sphenophyllum erosum, Lindley & Hutton, Fossil Flora, vol. i., pl. xiii.

Rotularia cuneifolia, Sternberg, Vers. i., fasc. ii., p. 33, pl. xxvi., fig. 4.

Rotularia pusilla, Sternberg, Vers. i., fasc. iv., p. xxxii.

Localities. Pit, Airdrie; Bent Colliery, about 1½ mile E. of Bothwell; Calderbank, near Airdrie.

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Sphenophyllum cuneifolium, var. saxifragæfolium, Brongniart.
S. cuneifolium, var saxifragæfolium, Coemans & Kickx., *Bull. l'Acad. roy. Belgique*, vol. xviii., p. 151, pl. i., fig. 6.

Localities. Whiterigg Pit, near Airdrie; Calderbank, near Airdrie.

FILICACEÆ.

SPHENOPTERIDEÆ.

RENAULTIA, Zeiller.

Renaultia microcarpa, Lesquereux, sp.

Sphenopteris microcarpa, Lesquereux, Coal Flora of Pennsyl., p. 280, pl. xlvii., fig. 2.
Sphenopteris microcarpa, Kidston, (*in part*) *Ann. & Mag. Nat. Hist.*, ser. 5, vol. x., p. 9, pl. i., figs. 9-14.
Renaultia (Sphen.) microcarpa, Zeiller, *Ann. d. Sciences Nat.*, 6e sér., Bot. vol. xvi., p. 185.

Remarks. The fruit of this species was first described by Lesquereux, but later and more fully by myself. It consists of small oval exannulate sporangia which are situated at the extremities of the veins.

Localities. Roof of Kiltongue Coal, Mount Vernon; Pit, near Airdrie.

SPHENOPTERIS, Brongniart.

Sphenopteris trifoliolata, Artis (not Brongniart).

Sphenopteris trifoliolata, Brongniart, Prodrome, p. 50.
Filicites trifoliolatus, Artis, Antedil. Phyt., pl. xi.

Remarks. Some of the specimens I refer to this species are in a good state of preservation for a satisfactory determination; hence the record of its occurrence in Lanarkshire is now corroborated.

Localities. Bent Colliery, about 1½ mile E. of Bothwell; Foxley, Shettleston; Caledonian Railway Cutting, Airdrie.

Sphenopteris obtusiloba, Brongniart.

Sphenopteris obtusiloba, Brongniart, Hist. d. végét. foss., p. 204, pl. liii., fig. 2*.
Sphenopteris irregularis, Andræ, Vorwelt Pflanzen, p. 24, pl. viii., pl. ix., fig. 1.
Sphenopteris irregularis, Sternberg, Vers. ii., p. 63, pl. xvii., fig. 4, p. 152, pl. ix., fig. 7.
Sphenopteris latifolia, Lindley & Hutton, Fossil Flora, vol. ii., pl. clvi., vol. iii., pl. clxxviii.

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Sphenopteris trifoliolata, Brongniart (not Artis), Hist. d. végét. foss., p. 202, pl. liii., fig. 3 (excl. refer.).

Remarks. Exceedingly fine specimens of this fern were collected.

Localities. Blaes between Kiltongue and Drumgray Coals, Whiterigg, near Airdrie; Foxley, Shettleston.

Sphenopteris furcata, Brongniart.

Sphenopteris furcata, Brongniart, Hist. d. végét. foss., p. 179, pl. xlix., figs. 4, 5.

Diplothmema furcatum, Zeiller, Végét. foss. du terr. houil. de la France, p. 45, pl. clxii., fig. 3.

Localities. Cutting, new Caledonian Railway, Airdrie; Black Pit, Longriggend, Slamannan; Calderbank, near Airdrie.

(?) *Sphenopteris* (*Hapalopteris*) *Schützei*, Stur.

Pl. III., fig. 5.

Hapalopteris Schützei, Stur. Die Carbon-Flora der Schatzlarer Schichten, p. 56, pl. xli., figs. 1-4. 1885.

Remarks. It is with considerable doubt that the fern shown at fig. 5 is placed under *Sphenopteris Schützei*, Stur. Several fruiting examples have been collected, but of what we regard as its barren condition, the small fragment given at fig. 5*b* is the most perfect. This has a great resemblance to Stur's *Sph. Schützei*, but notwithstanding the full description he gives of his fern, without accompanying good figures, it is almost impossible to identify many of the small pinnuled sphenopteroids.

The barren pinnules on the Calderbank examples are oval-lanceolate, and divided into from 4 to 5 linear obtuse segments, which in some cases are notched. The fruiting specimens possess the same characters, but are somewhat laxer, and bear sporangia at the extremities of the pinnule segments, into each of which extends a vein.

I have not been able to discover the ultimate structure of the sporangia, whether annulate or exannulate. One peculiar feature in regard to these fossils consists in the sporangia always adhering to the counterpart, leaving only a hollow depression on the fossil to mark their position.

Locality. In debris brought up while digging the foundation to the new Caledonian Railway Bridge, Calderbank, about 2 miles south of Airdrie.

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Sphenopteris (Hapalopteris) amœna, Stur.

Hapalopteris amœna, Stur, Die Carbon. Flora d. Schatzlarer Schichten, p. 52, pl. xli., fig. 7. 1885.

Sphenopteris microcarpa, Kidston (not Lesqx) *in part*, *Proc. Roy. Phys. Soc. Edin.*, vol. vii., pl. i., figs. 7 and 8. 1882.

Remarks. This species (*Sphen. amœna*) I previously united with *Renaultia* (*Sphenopteris*) *microcarpa*, Lesqx, regarding it as only a variety of that fern.

What I described as the fruit of *Renaultia microcarpa* in the *Proceedings of the Roy. Phys. Soc. Edin.*, vol. vii., pl. i., figs. 9–14, belongs however to *R. microcarpa*, and not to *Sphenopteris* (*Hapalopteris*) *amœna*.

Locality. Foxley, near Shettleston.

Sphenopteris, sp.

Remarks. The specimens I place here have a great resemblance to *Sphenopteris rotundifolia*, Andræ ("Vorweltliche Pflanzen," p. 37, pl. xii.), but, as it is necessary to use great care in recording the occurrence of a species, I will refrain at present from applying the specific name of "*rotundifolia*, Andræ," to them, and await further evidence before definitely determining this fern. But to whichever species this plant belongs, these examples are the first I have seen.

Locality. Blaes between Kiltongue and Drumgray Coals, Whiterigg, near Airdrie.

URNATOPTERIS, Kidston.

(?) *Urnatopteris tenella*, Brongniart, sp.

Urnatopteris tenella, Kidston. *Quart. Journ. Geol. Soc.*, vol. xl., p. 594.

Sphenopteris tenella, Brongniart, Hist. d. végét. foss., p. 186, pl. xlix., fig. 1.

Remarks. The specimens included here are somewhat larger in all their parts than typical *U. tenella;* in other respects they do not differ.

They have, however, a considerable resemblance to *Sphenopteris herbacea*, Boulay, which has little to distinguish it from *U. tenella*, except its slightly larger size.

Locality. Calderbank, about two miles south of Airdrie.

MARIOPTERIS, Zeiller.

Mariopteris, Zeiller, *Bull. Soc. Geol. de France*, 3e sér., vol. vii., p. 92; Végét. foss. du terr. houil. de la France, p. 68 (from vol. iv., de l'explication de la carte géologique de la France, 1880).

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This genus was founded by Zeiller to include certain ferns which, among other characters, are distinguished by a peculiar dichotomizing of their pinnæ. The primary pinnæ are attached to the rachis by a naked stalk, which bifurcates at a very obtuse angle; each of the forks of this first dichotomy again bifurcates, forming the secondary pinnæ, on which are borne the tertiary pinnæ, which in turn support the pinnules.

Mariopteris latifolia, Brongniart, sp.

Mariopteris latifolia, Zeiller, *Bull. Soc. Géol. de France*, 3e sér., vol. vii., p. 92, pl. vi.

Sphenopteris latifolia, Brongniart, Hist. d. végét. foss., p. 205, pl. lvii., figs. 1-4.

Locality. Roof of the Kiltongue Coal, Mount Vernon.

Mariopteris muricata, Schlotheim, sp.

Mariopteris muricata, Zeiller, *Bull. Soc. Géol. de France*, 3e sér., vol. vii., p. 92.

Pecopteris muricata, Brongniart, Hist. d. végét. foss., p. 352, pl. xcv., figs. 3, 4, and pl. xcvii.

Filicites muricatus, Schlotheim, Flora d. Vorwelt, p. 54, pl. xii., figs. 21 and 23.

Localities. Bent Colliery, about 1½ mile E. of Bothwell; Whiterigg Colliery, near Airdrie; Calderbank.

Mariopteris nervosa, Brongniart, sp.

Mariopteris nervosa, Zeiller, Végét. foss. du terr. houil. de la France, p. 69, pl. clxvii., figs. 1-4.

Pecopteris nervosa, Brongniart, Hist. d. végét. foss., p. 297, pl. xciv., and pl. xcv., figs. 1, 2.

Pecopteris nervosa, Lindley & Hutton, Fossil Flora, vol. ii., pl. xciv.

Remarks. Some of the specimens are very fine.

Localities. Bent Colliery, about 1½ mile E. of Bothwell; Calderbank; Pit near Calder Iron Works, Airdrie.

NEUROPTERIS, Brongniart.

Neuropteris heterophylla, Brongniart.

Neuropteris heterophylla, Brongniart, Hist. d. végét. foss., p. 243, pl. lxxi., and pl. lxxii., fig. 2.

Neuropteris heterophylla, Zeiller, Végét. foss. du terr. houil. de la France, p. 49, pl. clxiv., figs. 1, 2.

Neuropteris Loshii, Brongniart, Hist. d. végét. foss., p. 242, pl. lxxii., fig. 1, and pl. lxxiii.

Cyclopteris trichomanoides, Brongniart, Hist. d. végét. foss., p. 49, pl. lxi., *bis*, fig. 4.

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Remarks. Some exceedingly fine specimens of this fern, from blaes lying between the Kiltongue and Drumgray Coals, which were brought up while driving a road, were collected by Mr. Dunlop at Whiterigg Pit, near Airdrie. These examples are the finest British specimens I have seen.

Several specimens of *Cyclopteris trichomanoides*, Brong., which at one time was supposed to form a distinct species of a different genus, have also been collected. These peculiar cyclopteroid pinnules were attached to the main rachis of the fern, and a figure showing their relation to the other parts of the frond has been given by Röhl (Vers. d. Steink.-Form. Westphalens, pl. xvii.). *Neuropteris heterophylla* and *Neuropteris Loshii* are now known to represent only different portions of the same species.

Localities. Blaes between Kiltongue and Drumgray Coals, Whiterigg, near Airdrie; new Caledonian Railway Cutting, Airdrie; roof of Kiltongue Coal, Mount Vernon (at the two last-mentioned localities pinnules of the so-called *Cyclopteris trichomanoides* also occurred); Bent Colliery, about 1½ mile E. of Bothwell; Pit near Coatbridge; Pit near Calder Iron Works, Airdrie; Foxley, Shettleston; Calderbank, near Airdrie.

Neuropteris gigantea, Sternberg.

Neuropteris gigantea, Sternberg, Vers. i., fasc. iv., p. xvi.; Brongniart, Hist. d. végét. foss., p. 240, pl. lxix.

Osmunda gigantea, Sternberg, Vers. i., fasc. ii., pp. 33, 36, pl. xxii.

Remarks. The specimen from Coatbridge shows the fern in circinate vernation.

Localities. Bent Colliery, about 1½ mile E. of Bothwell; Coatbridge; Mount Vernon.

Neuropteris macrophylla, Brongniart.

Neuropteris macrophylla, Brongniart, Hist. d. végét. foss., p. 235, pl. lxv., fig. 1.

Osmunda, Scheuchzer, Herbarium diluvianum, p. 37, pl. x., fig. 3 (ed. 1709).

Remarks. The synonymy of this species is in a very unsatisfactory state; I therefore refrain from giving any further references.

Neuropteris macrophylla, which is one of the earliest figured ferns, occurs plentifully in some of the English Coal-fields; but the examples from Whiterigg are the first I have seen from a Scotch locality. Some of the specimens are very good, and show

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attached to the main axis large cyclopteroid pinnules, analogous to those to which reference has already been made in regard to *Neuropteris heterophylla*, Brong.

Locality. Whiterigg Pit, near Airdrie.

ALETHOPTERIS, Sternberg.

Alethopteris lonchitica, Schlotheim, sp.

Alethopteris lonchitidis, Sternberg, Vers. i., fasc. iv., p. xxi.
Pecopteris lonchitica, Brongniart, Hist. d. végét. foss., p. 275, pl. lxxxiv.; Lindley & Hutton, Fossil Flora, vol. ii., pl. cliii.
Pecopteris heterophylla, Lindley & Hutton, Fossil Flora, vol. i., pl. xxxviii.

Remarks. This is one of the commonest ferns of the Scotch Coal-measures, and is subject to great variation. To many of these varieties specific names have been given.

Localities. Roof of Kiltongue Coal, Mount Vernon; Bent Colliery, about $1\frac{1}{2}$ mile E. of Bothwell; Whiterigg Colliery, near Airdrie; Foxley, Shettleston (and *var. Mantelli*); Calderbank, near Airdrie.

RHACOPHYLLUM, Schimper.

(?) *Rhacophyllum filiforme*, Gutbier, sp.

Fucoides filiformis, Gutbier, Vers. d. Zwickauer Schwarzkohlengebirges, p. 12, pl. i., fig. 9.

Remarks. Among the fossils is a small specimen of *Rhacophyllum* with filiform segments, which, though not very well preserved, is, I believe, referable to this species.

Locality. New Caledonian Railway Cutting, Airdrie.

LYCOPODIACEÆ.

LEPIDODENDRON, Sternberg.

Lepidodendron Sternbergii, Brongniart.

Lepidodendron Sternbergii, Brongniart, Prodrome, p. 85; Lindley & Hutton, Fossil Flora, vol. i., pl. iv., vol. ii., pl. cxii., vol. iii., pl. cciii.
Lepidodendron dichotomum, Sternberg (*in part*), Vers. i., fasc. i., pp. 19, 23, pls. i., ii. (excl. pl. iii.); and Vers. ii., p. 177, pl. lxviii., fig. 1.
Lepidodendron elegans, Hist. d. végét. foss. vol. ii., pl. xiv.;, Lindley & Hutton, Fossil Flora, vol. ii., pl. cxviii., vol. iii., pl. cxcix.
Lepidodendron gracile, Lindley & Hutton, Fossil Flora, vol. i., pl. ix.; Brongniart, Hist. d. végét. foss., vol. ii., pl. xv.
Lepidodendron lycopodioides, Sternberg, Vers. i., fasc. 2, p. 31, pl. xvi., figs. 1, 2, and 4.

Remarks. One or two very fine specimens of that form of *Lepidodendron Sternbergii* which has been named *L. lycopodioides*

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by Sternberg and *L. elegans* by Brongniart were collected from a cutting on the new Caledonian Railway, near Airdrie.

Lepidodendron elegans and *L. gracile* appear to be only the younger and smaller branches of *Lepidodendron Sternbergii*, and not specifically distinct from that plant.

Localities. Cutting on new Caledonian Railway, Airdrie (*L. elegans*); Pit, Airdrie (*L. Sternbergii*); Bent Colliery, about $1\frac{1}{2}$ mile E. of Bothwell (*L. gracile*); Gartness, near Airdrie; Brownieside Pit, Plains, near Airdrie (*L. gracile*).

Lepidodendron aculeatum, Sternberg.

Lepidodendron aculeatum, Sternberg, Vers. 1, fasc. 1, pp. 20 and 23, pl. vi., fig. 2, pl. viii., fig. 1*b*; fasc. 2, p. 25, pl. xiv., figs. 1, 2, 3, 4, and fasc. 4, p. x.

Locality. Mount Vernon.

Lepidodendroid Branches.

Under this head I include two fine slabs from Whiterigg, which show on their surface a number of delicate twigs, measuring in some cases 10 or 11 inches in length, and about $\frac{1}{4}$ inch wide at their broadest part, including the leaves. The stems which bear the leaves are a little more than one tenth of an inch thick. The branches diminish gradually in width towards their apex. The leaves are very narrow, and about one fifth of an inch long. These two fossils are similar to those figured by Röhl as *Lycopodites selaginoides* ("Fossile Flora der Steinkohlen-Formation Westphalens," pl. vii., fig. 3).

I prefer, however, to record these specimens merely as Lepidodendroid twigs, rather than to place them under *Lycopodites*, for this genus, as founded by Brongniart, contained a number of Coniferous branches and small twigs of *Lepidodendron*, and was subsequently given up by that author; but *Lycopodites*, as resuscitated by Goldenberg,* contains certain plants very closely related to the recent genus *Lycopodium*, and quite distinct from *Lepidodendron*, and as the specimens from Whiterigg appear to be only young twigs of *Lepidodendron* (though of which species of *Lepidodendron* I am unable to say), they cannot be referred to *Lycopodites*, as restricted by Goldenberg.

* Goldenberg, "Flora Saræpontana fossilis," heft i., pp. 9, 10. 1855. See also Kidston, *Ann. & Mag. Nat. Hist.*, Aug. 1884, p. 111.

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Locality. Blaes between Kiltongue and Drumgray Coals, Whiterigg, near Airdrie.

LEPIDOPHLOIOS, Sternberg.

Lepidophloios carinatus, Weiss.

Lepidophloios carinatus, Weiss, Foss. Flora d. jüng. Steink. w. d. Rothl. p. 155, Kidston, Catalogue of the Palæozoic Plants in the British Museum, p. 172. 1886.

Remarks. Several specimens of this species have been collected.

Localities. Pit near Coatbridge; and in debris taken from the foundation of the new Caledonian Railway Bridge, Calderbank.

LEPIDOPHYLLUM, Brongniart.

Lepidophyllum lanceolatum, Lindley & Hutton.

Lepidophyllum lanceolatum, Lindley & Hutton, Fossil Flora, vol. i., pl. vii., figs. 3, 4.

Remarks. In *Lepidophyllum* are placed isolated bracts and leaves, which apparently belong in part to *Lepidodendron*, *Lepidophloios*, and *Sigillaria*.

Localities. Pit, Airdrie. Bent Colliery, about 1½ mile E. of Bothwell.

Lepidophyllum intermedium, Lindley & Hutton.

Lepidophyllum intermedium, Lindley & Hutton, Foss. Flora, vol. i., pl. xliii., fig. 3.

Locality. Calderbank, near Airdrie.

LEPIDOSTROBUS, Brongniart.

Lepidostrobus variabilis, Lindley & Hutton.

Lepidostrobus variabilis, Lindley & Hutton, Fossil Flora, vol. i., pls. x., xi.

Remarks. Under this name are most probably included the cones of different species of Lycopods.

Localities. Blackband, Airdrie; Bent Colliery, about 1½ mile E. of Bothwell; Mount Vernon; Pit near Calder Iron Works, Airdrie.

Lepidostrobus, sp.

Localities. Mount Vernon; Pit near Calder Iron Works, Airdrie.

SIGILLARIA, Brongniart.

Sigillaria discophora, König, sp.

Lepidodendron discophorum, König, Icones fossilium sectiles, pl. xvi., fig. 194. 1825.

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Ulodendron majus, Lindley & Hutton, Fossil Flora, vol. i., pl. v. (excl. ref.).

Ulodendron minus, Lindley & Hutton, Fossil Flora, vol. i., pl. vi. (excl. ref.).

Remarks. *Ulodendron minus*, L. & H., is only a smaller specimen of their *Ulodendron majus*, and both are similar to the plant described by König as *Lepidodendron discophorum*.

It is now known that certain *Ulodendra*, such as *U. parmatum*, Carruthers (= *U. commutatum*, Schimper), belong to *Lepidodendron Veltheimianum*, Sternberg, and there are other *Lepidodendra* which also bear Ulodendroid scars. But in addition to *Lepidodendra*, some Clathrarian *Sigillariæ* were likewise provided with Ulodendroid scars, of which *Sigillaria discophora* is an example. Ulodendroid scars also occur in the genus Bothrodendron, L. & H.(= *Rhytidodendron*, Boulay). The presence of these large scars cannot then be regarded as a generic character. The leaf-scars only afford the necessary comparative points for the classification of these so-called Ulodendroid Lycopods, and the leaf-scars of *Sigillaria discophora* are essentially those of a Clathrarian *Sigillaria*.

Localities. Pit near Airdrie; Toad Pit, near Airdrie.

Sigillaria notata, Steinhauer, sp.

Sigillaria notata, Brongniart, Hist. d. végét. foss., p. 449, pl. cliii., fig. 1.
Phytolithus notatus, Steinhauer, *Amer. Phil. Trans.*, vol. i., pl. vii., fig. 3.

Remarks. This collection contains only one small specimen of this species, with narrow ribs and proportionately small leaf-scars. The leaf-scars are more distinct than figured by Brongniart; but in this character the plant varies much.

Locality. Bent Colliery, about 1½ mile E. of Bothwell.

Sigillaria, sp.

Remarks. I place here a small decorticated example of a *Sigillaria*, which, in the absence of the outer surface of the stem, does not afford sufficient characters for a specific identification. It is the *Sigillaria* (*Syringodendron*) *cyclostigma*, Brong. (Hist. d. végét, foss., pl. clxvi., fig. 3), of which, however, nothing more can be said than that it is a decorticated condition of a *Sigillaria*.

Locality. Baillieston.

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Bothrodendron minutifolium, Boulay, sp.

Bothrodendron minutifolium, Zeiller, *Bull. Soc. Géol. de France*, 3e sér., vol. xiv., p. 176, pl. ix., figs. 1, 1*a*, 1*b*, and 1*c*. 1885.

Rhytidodendron minutifolium, Boulay, Le terrain houiller du nord de la France et ses végétaux fossiles, p. 39, pl. iii., figs. 1 and 1 bis. 1876.

Remarks. Till lately I regarded the genus *Bothrodendron*, Lindley & Hutton, as only founded on a decorticated condition of their *Ulodendron*, and in this view I was supported by many British botanists.

Zeiller, however, has shown that *Bothrodendron*, Lindley & Hutton, is a true genus, and at my request has kindly figured an authentic specimen of *Bothrodendron punctatum* from Newcastle (Zeiller, l.c., pl. viii., fig. 1), which was presented under that name by Dr. Hutton to the Museum d' Histoire Naturelle de Paris, in 1836. (Number in Museum Catalogue, 1367). It has been further shown that the genus *Rhytidodendron*, Boulay (in which I formerly placed *B. minutifolium*), is none other than *Bothrodendron*, Lindley & Hutton. It is a very remarkable circumstance that, though I have carefully searched, I have not yet discovered in Britain, either in museums or private collections, a single specimen of *Bothrodendron punctatum*, and, as far as can be ascertained, the Newcastle examples, of which there are three in the Museum of Nat. Hist., Paris, are the only British examples of this species extant. The plants, therefore, that I included under *Rhytidodendron* in my paper, "On the Relationship of *Ulodendron* to *Lepidodendron*, etc. (*Annals and Mag. Nat. Hist.*, 1885, p. 174) must be transferred to *Bothrodendron*, and also *Bothrodendron punctatum* must be removed from the synonymy of *Sigillaria discophora*, König, sp., and regarded as a true species (*Annals and Mag. Nat. Hist.*, l.c., 1885, p. 251).

At Calderbank some good specimens of *Bothrodendron minutifolium* were collected, a few showing the smaller branches with the foliage still attached.

Locality. Debris from foundation of new Caledonian Railway Bridge, Calderbank, about two miles south of Airdrie.

Lycopod Spores.

Remarks. These are probably the spores of *Lepidodendron* or *Sigillaria*. They are about $\frac{1}{25}$ inch in diameter, and apparently

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belong to Reinsch's group Triletes.* These little spores almost entirely cover the surface of some small slabs, and are restricted to the "parting" of the stone.

Locality. Blaes at old pit, near Airdrie.

STIGMARIA, Brongniart.

Stigmaria ficoides, Brongniart.

Stigmaria ficoides, Brongniart, Class. d. végét. foss., p. 9, pl. i., fig. 7; Lindley & Hutton, Fossil Flora, vol. i., pls. xxxi.-vi.

Stigmaria ficoides (and vars.), Göppert, Gatt. d. foss. Pflanzen, lief. 1, 2, p. 13, pls. viii.-xvi.

Remarks. Stigmariæ, the roots of *Lepidodendron* and *Sigillaria*, are common throughout the whole of the Coal-measures. The specimen from Airdrie shows a transition from the Lepidodendroid leaf-scar to the Stigmarian root-scar. The Stigmarian vascular scar is here surrounded by a "field," similar to that which surrounds the vascular impression of the Lepidodendroid leaf-scar.

Stigmaria ficoides, var. *reticulata* (Göppert), has also been met with.

Localities. Common throughout the whole district. *Stigmaria ficoides*, var. *reticulata*, above oil-shales, Airdrie.

CYCADACEÆ.

CORDAITES, Unger.

The internal organization of the leaves, flowers, and stems of *Cordaites* has been fully described by Grand'Eury and Renault.† According to Grand'Eury, the stems of *Cordaites* attained a height of from 20 to over 30 feet, and were irregularly ramified. At the upper extremities of the branches and stems were borne the long narrow leaves. In *Cordaites* the pith was chambered, and the curious fossils, variously called *Sternbergia* or *Artisia*, are casts of its pith-cavity.

The wood in structure approaches closely to that of the Coniferæ, and was previously described as *Pinites Brandlingii* by Witham.

* "Micro-Palæo-Phytologia Formationis Carboniferæ," vol. i., p. 1, 1884. (Vols. i. and ii. Erlangen, Bavaria, 1884. Many hundreds of these organisms are figured in this work.)

† For a full description of the structure of *Cordaites*, see Renault, "Cours de botanique fossile," première année, Paris, 1881; Grand'Eury, "Flore carbonifère du Département de la Loire et du centre de la France," 1877; Zittel-Schenk, "Handbuch der Paläontologie," ii. band, lief. iii., p. 241, 1884.

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It is also most probable that many of the fossil woods referred to *Pinites*, Witham (*Araucarioxylon*, Kraus; *Araucarites*, Göppert), are portions of the stems of *Cordaites*. The wood-fibres bear one or many vertical rows of bordered pits. The leaves are more or less long in proportion to their width; and from characters derived from these organs, Grand'Eury proposes for *Cordaites* the three following divisions:—

I. *Eucordaites*.—Leaves spathulate, obovate, elliptical, or lanceolate, sessile, entire, with rounded apices and of leathery consistency. The leaves are from 20–90 centim. in length. The nerves are either equally or unequally strong.

II. *Dorycordaites*.—Leaves lanceolate with sharp points; nerves numerous, fine, and equal in strength. The leaves attain a length of from 40–50 centim.

III. *Poacordaites*.—Leaves narrow, linear, entire, blunt at the point, with nerves nearly equally strong. The leaves are as much as 40 centim. in length.*

The flowers of *Cordaites* are monœcious. The male flowers consist of a number of imbricated bracts, in the axils of which are situated the stamens, or they are placed around the depressed apex of the axis of inflorescence. The female flower contains several naked ovules, which are short-stalked and set in the axils of the bracts. Their fertilization takes place in a somewhat similar manner to that of the Cycads and Conifers. During the maturation of the fruit the short stalk, to which the seed is attached, in some cases becomes much elongated, as in *Cardiocarpus* (*Cordaianthus*) *Lindleyi*, Carruthers, and *Cardiocarpus anomalus*, Morris, sp. In very few cases have the flowers been found in union with their parent stems, so till we know to which species of *Cordaites* the isolated inflorescences and fruits belong, it is necessary to apply to them specific names in order that their occurrence may be recorded. The structure of the seeds has been investigated by Brongniart.†

* Since writing the above a new type of *Cordaites* has been described by Renault and Zeiller, which they have named *Scutocordaites*, '*Comptes Rendus*,' March 23, 1885.

† Brongniart, "Recherches sur les graines fossiles silicifiées," Paris, 1881. Also, "Études sur les graines fossiles trouvées à l'état silicifié dans le terrain houiller de Saint Etienne," *Annales des Sciences Nat. botan.*, 5e sér., vol. xx., pls. xx.-xxiii.

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From the results of the observations of those botanists who have been successful in securing specimens preserved in silica, in which the most minute details of structure are exhibited, even to the pollen-grains, it appears that *Cordaites* must be looked upon rather as a *group* of plants than a *genus*. In certain structural points *Cordaites* approaches closely to the Coniferæ, in other respects to the Cycads; but taking into account all the structural peculiarities of the plants, their affinities appear to be more Cycadaceous than Coniferous.

I have given but a meagre outline of the organization of these plants, and must refer those who are interested in the subject to the original works of the authors quoted.

From the fragmentary manner in which *Cordaites* usually occurs, the chief specific characters are derived from the nervation of the leaves.

Cordaites (*Eucordaites*) *principalis*, Germar, sp.

Cordaites principalis, Geinitz, Vers. d. Steinkf. in Sachsen, p. 41, pl. xxi., figs. 1-6 (excl. fig. 22).

Cordaites principalis, Weiss, Foss. Flora d. jüng. Stk. u. d. Rothl., p. 200.

Flabellaria principalis, Germar, Vers. v. Wettin. u. Löbejun, p. 55, pl. xxiii.

Pycnophyllum principale, Schimper, Traité de paléont. végét., vol. ii., p. 181.

Description. Leaves long, attaining a length of from 12 to 18 inches, and sometimes rather over 2 inches wide, narrowed towards the base and again narrowing towards the apex, the extreme point of which is rounded or obtuse; seven or eight of the stronger nerves in one tenth of an inch, between which are from three to five finer (?) nerves.

Remarks. In well-preserved specimens there are seen running parallel with and between the strong nerves from three to five fine lines. These are described by Geinitz as vertical rows of cells, and his fig. 2, pl. xxi., shows these finer lines strongly magnified, and certainly they here appear more like rows of tabular cells than veins; but Weiss, in his description of the species, calls them nerves. Only very perfectly preserved specimens can decide whether the finer lines placed between the strong nerves are rows of cells or finer nerves.

The plant included here I have little doubt is Germar's species. It is very frequent in the Scotch Coal-fields.

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Localities. Bent Colliery, about 1½ mile E. of Bellshill; Pit near Calder Iron Works, Airdrie.

CARDIOCARPUS, Brongniart.

Cardiocarpus (*Cordaianthus*) *Lindleyi*, Carruthers.

Cardiocarpon Lindleyi, Carruthers, Notes on some Fossil Plants, figs. 1 and 2, *Geol. Mag.*, vol. ix., 1872.

Cardiocarpon acutum, Lindley & Hutton, Fossil Flora, vol. i., pl. lxxvi.

Cardiocarpon apiculatum, Berger & Göppert, Fruct. et. semin., p. 23, pl. ii., fig. 32.

Antholithes Pitcairniæ, Lindley & Hutton, Fossil Flora, vol. ii., pl. lxxxii.

Remarks. These little seeds have been found attached to stems, which were previously called *Antholithes Pitcairniæ*, Lindley & Hutton, by Mr. C. W. Peach, at the Cleuch, Falkirk, and have been described and figured by Mr. Carruthers in the *Geol. Mag.*, vol. ix., 1872.

As *Cardiocarpon Lindleyi* is almost invariably found associated with *Cordaites principalis* it is perhaps the fruit of that species.

Localities. Bent Colliery, Bellshill; Foxley, Shettleston.

CORDAIANTHUS, Grand'Eury.

Cordaianthus, sp.

Remarks. This specimen is probably a young condition of *Antholithes Pitcairniæ*, L. & H., and is the female inflorescence of a *Cordaites*. The fossil shows an axis 3½ inches long, and at its basal extremity it is fully $\frac{1}{10}$ inch wide. On each side of the stem is a vertical row of alternate bracts, from the axils of some of which traces of fruit-pedicels can be seen. Each row contains about twenty groups of bracts; those at the base of the inflorescence are about $\frac{1}{5}$ inch long and rather less than $\frac{1}{10}$ inch wide; but they become slightly smaller and more distant towards the upper part of the specimen, of which, however, the extreme apex is wanting. The structure and number of bracts in each group is not shown. On the same slab is a specimen of *Cardiocarpus Lindleyi*. This example of *Cordaianthus* was found associated with *Cordaites principalis*, Germar, sp.

Locality. Bent Colliery, about 1½ mile E. of Bothwell.

Cordaites Stems.

Notwithstanding the frequent occurrence of *Cordaites* leaves throughout the whole of the Scotch coal measures, extremely

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seldom are any stems found. Mr. Dunlop has been successful in discovering two small specimens, both of which are well preserved.

Locality. Brownieside Pit, Mains, near Airdrie.

Of uncertain affinity.

TRIGONOCARPUS, Brongniart.

Trigonocarpus Parkinsoni, Brongniart.

Trigonocarpum Parkinsonis, Brongniart, Prodrome, p. 137.

Trigonocarpum Noeggerathii, Lindley & Hutton (not Sternberg), Fossil Flora, vol. ii., pl. cxlii. C; vol. iii., pl. cxciii., figs. 1-4 B, pl. ccxxii., figs. 2 and 4.

Remarks. Carpolithes alatus, Lindley & Hutton (Fossil Flora, vol. ii., pl. lxxxvii., vol. iii., pl. ccx. B), appears to be only *Trigonocarpus Parkinsoni* enclosed in its pericarp. It is not yet discovered to which plant these seeds belong.

Specimens of *Trigonocarpi* have been found in which the internal structure was preserved, and these show that it is Gymnospermous.

Localities. Roof of Kiltongue Coal, Mount Vernon; Pit near Coatbridge.

RHABDOCARPUS, Göppert & Berger.

Rhabdocarpus elongatus, n.s.

Pl. III., fig. 6.

Description. Seed narrow-oblong, rounded at the apex, and gradually contracting from the centre into a stalk-like pedicel. The exposed surface bears four longitudinal ridges.

Remarks. The figure shows a perfect specimen and portion of a second. From the position these two seeds hold to each other; they were probably attached to the same stem, but this cannot be determined.

Rhabdocarpus elongatus approaches very closely to *R. orientalis* as figured by Schmalhausen from the Lower Carboniferous of the Eastern Urals, (*Mem. de l'Acad. Impér. d. Sc. St. Pétersbourg*, vol. xxxi., no. 13, pl. iv., fig. 15), but is narrower in proportion to its length.

The more perfect specimen of *R. elongatus* figured on Pl. III., fig. 6, is 15 mm. long and 3 mm. wide. The specimens, however, vary slightly in size.

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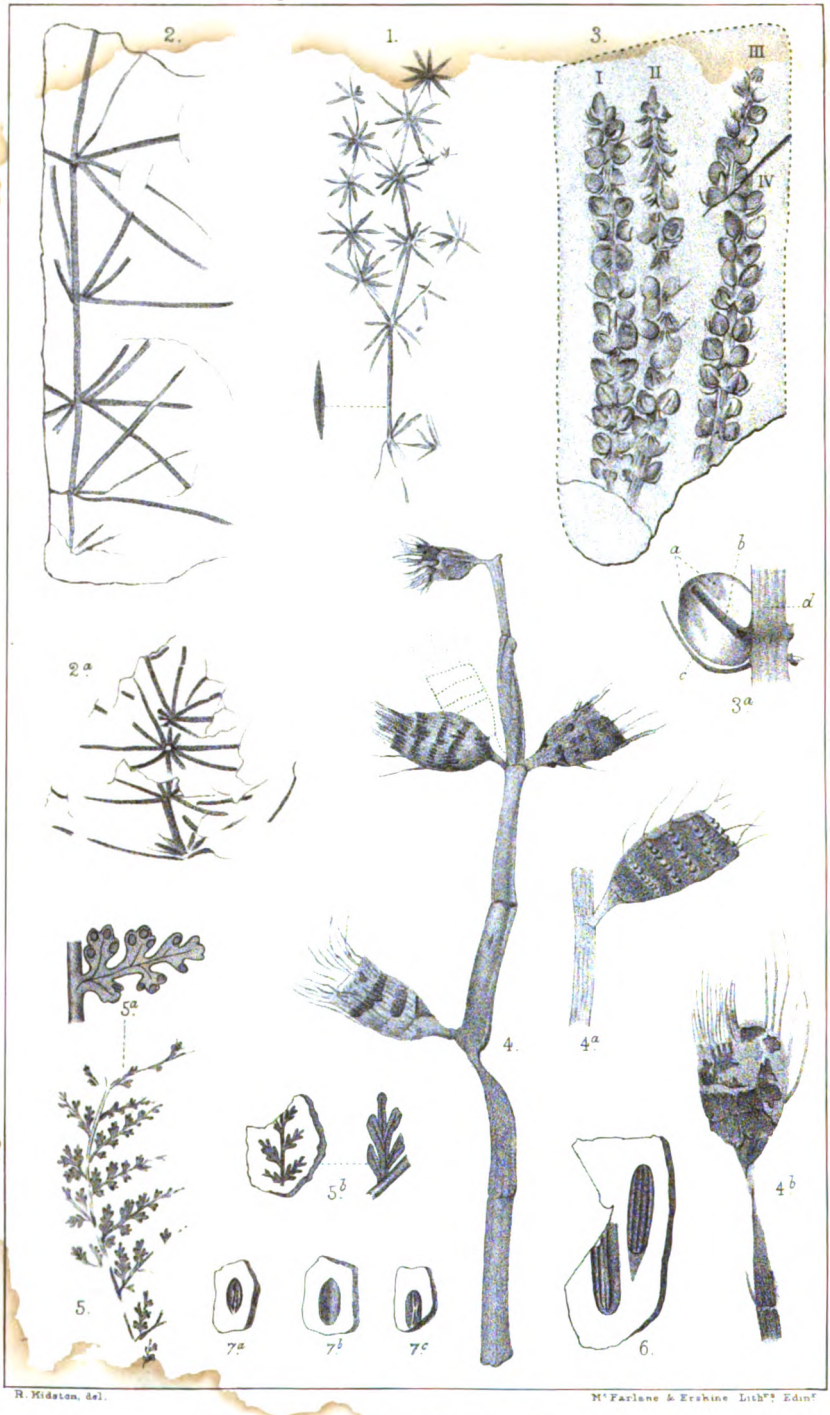

R. Kidston, del. M^c Farlane & Erskine Lith^rs Edin^r

CARBONIFEROUS FOSSIL PLANTS.

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Locality. Debris taken from the foundation of the new Caledonian Railway Bridge, Calderbank, about three miles south of Airdrie.

CARPOLITHUS, Sternberg.

Carpolithus bivalvis, Göppert.

Pl. III., fig. 7.

Carpolithes bivalvis, Berger & Göppert. De fructibus et seminibus ex formatione lithanthracum, p. 26, pl. ii., figs. 30 and 31.

Description. Small oval bodies about 5 mm. long and 2 mm. broad. Outer surface smooth.

Remarks. The nature of these small fossils is somewhat obscure. It is probable they are sporangia.

Locality. Pit near Kirkwood.

EXPLANATION OF PLATE. III.

FIG. 1. Foliage of *Calamites ramosus* (*Annularia radiata*, Brong.). Fig. 1*a*. One of the leaflets magnified. Specimen from Airdrie.

FIG. 2. *Annularia patens*, Sauveur. From pit near Airdrie. 2*a*. *Annularia patens*, Sauveur. From Furnace Bank Colliery, Old Sauchie, near Alloa, Clackmannanshire.

FIG. 3. *Palæostachya gracillima*, Weiss. From Calderbank, near Airdrie. Fig. 3*a*. Enlargement of portion of verticil showing *sporangium* (*a*) with its sporangiophore (*b*), sitting in the axil of the bract (*c*), axis of cone (*d*).

FIG. 4. (?) *Calamostachya longifolia*, Weiss. From Calderbank, near Airdrie. Figs. 4*a* and 4*b*. Two other isolated cones.

FIG. 5. (?) *Sphenopteris Schützei*, Stur. From Calderbank, near Airdrie. Fig. 5. Fertile portion. Fig. 5*a*. Fertile pinnule enlarged. Fig. 5*b*. Small fragment of barren condition.

FIG. 6. *Rhabdocarpus elongatus*, Kidston, n.s. From Calderbank, near Airdrie.

FIG. 7. *Carpolithus bivalvis*, Göppert. From pit near Kirkwood. Natural size.

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No. V.—The Joint Excursion of the Edinburgh and Glasgow Geological Societies to Ben Nevis and the Parallel Roads of Lochaber, in July, 1885. By William Jolly, F.R.S.E., F.G.S., Leader of the Excursion.

[Read 12th November, 1885.]

Introduction.—On the 7th of May, 1885, I delivered an expository lecture before the Edinburgh Geological Society, and repeated the same on the 14th before this society, on "The Parallel Roads of Glen Roy: the Problem, its Conditions, and Solutions."* One result of these papers was that a joint excursion of members of both societies was arranged for Lochaber, to examine the problem on the spot, under the leadership of the lecturer. The excursion took place during the last week of July, from Monday, July 27th, to Saturday the 31st. The party numbered seventeen in all, of whom six were connected with the Edinburgh Society and nine with the Glasgow Society, another being a gentleman from Dorset, and the last Mr. Colin Livingstone, head master of the Public School of Fort-William, whose knowledge of the district and of the special subject is unrivalled, and whose services were of the greatest value to the party, as duly and heartily acknowledged. The whole cost of the excursion to each man was, on an average, about £5. The weather was superb, without a single shower; the sky cloudless and the air uncommonly clear, exhibiting the glorious scenery and the various phenomena to the best advantage; the party delightfully varied, bright and genial; and the whole experiences unusually pleasant, instructive, and memorable.

The time at disposal did not and could not allow of detailed investigation of the numerous and difficult points involved, scattered, as these are, over a broad mountainous district, and necessitating, as they undoubtedly do, the patient and minute observation of years, to be adequately mastered. All that could be attempted was to obtain a general idea of the numerous conditions of the problem, as exhibited on the spot, to see the wide and varied mountains and glens where they occur, and to examine somewhat more carefully some of the chief phenomena that require explana-

* See page 40.

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tion; in order not so much to come to a decision then and there, as to enable the inquirers the better to comprehend the abundant literature on the subject, more intelligently to criticise the theories advanced, and finally help them to arrive at the most probable, if not the true, solution of this difficult and ever fascinating subject.

The present paper is intended to give a short account of the scientific side of the excursion only, leaving out the delightful scenic and social elements, which were not more pleasant than profitable, and which give to such excursions the rare union of intellect and feeling that makes them so delightful. The party found in Lochaber, as we all have pleasantly experienced elsewhere, that sociality may be united with science, and that even geology is no enemy to jollity.

I. BEN NEVIS.—*Monday, May 27th.*

1. From Oban to Fort-William.—The most of the party met at Oban, the Edinburgh members reaching it by steamer, and the Glasgow by rail. There we visited the marked junction of the Conglomerate with the underlying nearly vertical Silurian slates, on the shore between Oban and Dunolly Castle, and the striking rocky stack, known as the Dog Stone, to which Fingal used to tie his huge hound, and which is an isolated mass of the Conglomerate of the ancient Lake Lorne of Old Red times; exhibiting, at a glance, its various constituents. During the voyage to Fort-William, the geology of the coast and surrounding country claimed attention—the trap region behind Oban, the age of which still requires final determination; the rounded granite outburst of Ben Cruachan, of which Loch Etive occupies the centre; the limestone of Lismore and Appin; the clearly marked "ancient sea margins," everywhere apparent along the shore, in flat continuous terraces, steep cliffs, old sea caves and rock arches now inland, excavated by the old waves; and the evidences of glaciation in *roches moutonnées* on sea and land, in the flowing outlines of the mountains, in moraine matter, and in the scratched and polished surfaces of the bare rocks we passed. The party was specially struck with the geological features seen at the entrance of Loch Leven, the syenite mass of Scuir Donuil above the pier, the limestones and marbles on both sides of the loch, the slates of Ballachulish; and the severe glacial action to which the whole has been subjected at this narrow

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outlet for the combined glaciers of Loch Leven and Glencoe, in remarkable striated surfaces easily noted from the steamer, and in the rubbed and smoothed outline of the well-named Scuir na Ciche, the Scuir of the Pap, set at the point between these two glens, whose graceful outlines were formed by the joint action of the glaciers that filled them and united below its front; the notable deposits of debris that form the peninsula of Corran or the Sickle, so named from its northern curve, a collection of soft materials which ought, at first sight, to have been swept away by the rapid currents that here rush through the Narrows, but which truly owe their preservation to these currents; and the schists and other rocks that form the straight and steep walls of Loch Eil north to Fort-William.

2. The Ascent.—The peak of Ben Nevis caught the eye shortly after leaving Loch Etive, and grew in massiveness and grandeur as we steamed northwards, clear to the summit. The unusual fineness of the weather naturally suggested the climbing of the big Ben that evening, and the idea was enthusiastically adopted and at once acted upon. After landing, Mr. Omond, the keeper of the summit observatory, and Fellow of the Edinburgh Society, who had been previously communicated with, was at once wired that he might look for us that night. The requisite arrangements having been quickly made, our waiting carriages carried us to the bridge of Nevis, where we began the ascent. Eleven of us took the hill—one on horseback, the rest on foot—and we all, with one exception, reached the top. The climbing took between four and five hours, and the last of the party, your humble servant, who, as whipper-in, had to bring up the rear, arrived at the Observatory a little after midnight. Though greatly favoured by the new, well-made and well-engineered path, which begins at the farm of Achintee, under the steep front of Meall-an-t-Suidhe, and which is four miles long, the ascent is still trying enough. It is, however, very much easier than it was, and it was manfully and smartly accomplished by the elders of the party, who took natural rests at intervals, of course, with the usual excuse of a desire the better to admire the scenery and examine the geology!

3. The Glen Nevis Glacier.—The lateral moraines of the Glen Nevis glacier are very well seen on both sides of the lower part of the glen, at different levels, curving round outwards along the western face of Meall-an-t-Suidhe, where the glacier, gradually

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expanding from its narrow bounds in the steep Glen Nevis, spread outwards on the flat moorland of the Great Glen. As pointed out by Jamieson, these rubbish mounds show no trace of water action by sea or lake, and must, therefore, have been deposited after the great depression of the land, in the middle of the Glacier Period, to the probable depth of some 2,000 feet, and during the latter part of this period, when the land had greatly reached its present level. If this had not been the case, the moraine debris would have shown more or less powerful traces of re-sorting by the waves, especially in such a narrow glen, with a summit level of only 1,217 feet, through which a strong current would stream east and west. These moraines are very well seen from the mountain road, as they appear on the south side of the glen, above Glen Nevis House, where they lie in continuous lines, at successive levels, as left by the shrinking ice.

The detritus on the side of the glen next Ben Nevis is so abundant, and rock surfaces are so comparatively rare, that ice scratchings are not often seen during the ascent. At several places, however, they are very good, especially on the slates and chloritic schists near the mouth; for the granite of the greater part of the journey, disintegrating easily, does not preserve striations well, though showing creditably general smoothing and stoss and lee sides. All scratches run parallel to the glen, and prove the movement of a great glacier, some 2,000 feet in depth at its greatest dimensions, which gradually shrunk into nothingness, and at its later stages deposited the heaped moraines that cover the lower parts of the valley. There they could more easily rest than on its higher very steep or precipitous sides.

4. The Geological Structure of Ben Nevis.—The rocks at the mouth of Glen Nevis can be very well observed in the bed of the river, at different points on the path, dipping at a high angle to the S.E. They consist of a series of schists, mostly chloritic, with beds of quartzose rocks, calcareous shales, and the slates of Ballachulish. Whether these are all Silurian, as mapped by Archibald Geikie, or Pre-Cambrian covered by Silurian, as contested for by Dr. Hicks, it is beside our present purpose to inquire. On the south side of the glen, the sedimentary rocks are continuous, and are cut through by intrusive porphyries, but they contain little granite. None of the limestone is seen here, though it appears so largely in the rocky ridge of Donie, a little to the north,

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at Blarmacfoldack, in the next glen to the south, and at Ballachulish—being worked at all these points.

The thick-bedded white Quartzite is similar in appearance and age to that which forms such a striking feature of the scenery at the head of Loch Maree, and at other parts of the N.W. coast, and has a large development in the upper reaches of the glen, especially on the south side. There it is seen to cap the chloritic series with the same S.E. dip; and it is itself overlaid by other slates and shales. Here, as everywhere else, it imparts grand and special characteristics to the scene. It forms the precipitous peaks of several of the highest summits, all above 3,000 feet, which form the magnificent mountain wall of Glen Nevis. Gleaming white, bare, and utterly barren, and often dazzling in the bright sunlight, it forcibly recalls some of the wild scenery of the West Coast, in which the chief element is the same or a similar Quartzite. This Quartzite, disintegrating easily, forms, in many cases, at Glen Nevis, rounded cones more or less pointed, called here from their shape *Stob*, a Gaelic word meaning a pin or point, and *Maim* or *Mam*, a word connected with the Latin *mamma*, a breast—both words aptly describing the form of the peaks. The adjective "Bahn," white, occurs frequently in the names of these hills, which are so called from the white Quartzite of their tops; as in Stob Bahn, 3,274 feet, immediately opposite Ben Nevis to the south, and another Stob Bahn, 3,217 feet, to the north of the summit level of Glen Nevis.

The new mountain path, which cost £1,800 to form, instead of following the old track past the distillery, along the *north* side of Meall-an-t-Suidhe, and thence between the lake and the Ben, takes the south side of the Meall, next Glen Nevis. It goes up the west side of the corry drained by the Alt na Urchaire, till it overlooks the lake on the south, and then winds over the broad shoulders of the mountain to the summit. Before the lake comes in view, it runs entirely over the slaty schists and their associated rocks, of which the Meall greatly consists. Beyond that, the igneous rocks that form the imperishable heart of Ben Nevis are soon entered on. These consist of a core of hardest porphyry—of different hues, but mostly dark—which forms the magnificent precipice of the Ben, some 1,500 feet sheer, and which faces Corry Lees to the north. This porphyry is surrounded on all sides, except at the precipice, by granite, both white and red, much, if not most, of the granite being syenitic. Both the porphyry and the granite have probably been

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intruded through the sedimentary schists, slates, and quartzites which enclose it on all sides. These continue to dip to the S.E., and, as put by Dr. Hicks, are tilted up at an unusually high angle, and stand apparently end-ways against the base of Ben Nevis.*

The red granite or syenite gives name to the mountains which immediately surround the porphyry peak of the Ben itself, the adjective Dearg meaning red,—Carn Dearg, 3,961 feet to the N.W. of the highest point, and another of the same name (3,348 feet) to the S.S.W., while the long mountain ridge on the north side of Corry Lees bears the same epithet, with three peaks—More, the Great Cairn (3,950 feet), Meadhonach, or the Middle Cairn (3,873 feet), and Beg, or the Little Cairn (3,264 feet). In this way, the porphyry heart of the Ben is enclosed on all sides by a granitic envelope, which rise into five mighty peaks, only a little lower than itself, all bearing the same descriptive title of Dearg or Red.† These form, in reality, one unbroken mighty mountain mass, in the middle of which has been scooped out the huge, wild hollow of Corry Lees, in front of the great precipice of the central dome. Besides this red granite, there is also a large development of a grey variety, which is well seen where it is crossed on the way to the top.

5. The Ben Nevis Observatory.—The night was balmy and clear, and showed the gradually darkening landscape, in varied and telling lights, with admirable effect. The moon was then at full, and on these upper heights looked beautifully bright, and more like the burnished silver mirror of southern latitudes than the leaden luminary of our misty land. It hung in the blue east, and was hidden from view for most of the time by the intervening mountain mass, as we climbed its western front. The shadow of the Ben, thrown on the back of Meall-an-t-Suidhe with a clearness of outline scarcely credible, was a singular and uncommon sight. At various points, we emerged into the moon's bright light, which only intensified the black shadows into which we dropped, and the moon did not rise permanently till we reached the highest flat of the hill.

The toilsomeness of the ascent is much increased by the broken

* *Proceedings of the Geologists' Association*, vol. vii., No. 1.

† In other parts of the Ben Nevis mountains, the appellation Dearg or red indicates the presence of a red porphyry, which is abundantly developed in the range.

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granite chips that compose the most of the path, all soil being quite washed out of it by the heavy rains and rapid runnels. The whole of the plateau at the summit consists of a layer of the same broken granite, porphyry and agglomerate, which shows a packed appearance, due no doubt to the pressure of the heavy snow field of the long-drawn winter. We were welcomed heartily and pleasantly by Mr. Omond and one of his assistants, the other being in bed; Mr. Omond himself always taking the night watch. The small but cozy reception room of the Observatory, crowded with our party, was a sight of rare picturesqueness at that midnight hour. As we sat round the warm stove, illuminated by the streaming lamp, cheered by the excellent tea, coffee, and abundant provision, and enlivened by much genial talk and high spirits, we looked, for all the world (especially with the somewhat exhausted condition of some of the members), like a crew of shipwrecked passengers from a wandering balloon in the coming years, stranded here and entertained by the kindly inmates of a lighthouse set in mid air.

6. The View from the Summit.—Before daybreak, we emerged from our comfortable cabin to examine the rocky islet on which we stood, this fancy being made the more real by the weird grey light that showed only our bare surroundings. The sight soon revealed by the slowly rising sun was wonderful, and impressive beyond description. The morning was clear to the farthest horizon. All around, especially to the south and east, stretched a rolling level ocean of unbroken white fleecy clouds, through which rose at intervals the peaks of the higher mountains, and beneath which, entirely hidden from view, lay the whole sleeping world. It was a vivid presentation of the aspect of the palæocrystic sea covered with a packed ice-floe, without a single berg; or it was a realization, to the eye, of the frozen sea in the middle of the last Glacial period, when the ocean stood two thousand feet above its present level, swathing all in ice, except the higher mountain tops, and enveloping the very mountain region on which we then looked down, while the whole glacial landscape was illuminated by the cold sun of the Arctic summer. The view stretched from Schiehallion on the east to the Uists on the west; Hecla in South Uist and the peaks of Harris being most distinct, away beyond the Isle of Skye and the serrated Coolins. It was such an expanse of view, seen under cloudless conditions, as is rare amid the western wet-

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ness, and such as I had never had before among my many clamberings on these mountains; and this was my third visit to the top. The fleecy sea, gradually melting away, revealed the more substantial ocean of glen and mountain which heaved its billowy crests round this central peak.

The view of Glen Nevis from the edge of the southern Carn Dearg was remarkable in the pearly grey light, as you looked right down into its profound gorge and its numerous lateral corries—the extensive nursing ground of the old glaciers that concentrated in the narrow glen and crushed their resistless way out of its mouth at Loch Eil, down Loch Treig, and south to Loch Leven and the Moor of Rannoch.

7. The Aspect of the Top.—Deep snow wreaths lay in the protected hollows of the wide stony plateau, and clustered to a great depth, hard and firm, round the edge of the mighty precipice. There, at the very end of July, we made snowballs, and threw them at each other like school boys, our hearts being then as light as in the early days. Several of the younger members sent great rocks plunging down the precipice, which were at once lost to view in the gloom, but sounded their thunderous way, to join the blocks that form the enormous talus of the cliff, detached by the frosts of ten thousand years.

After accompanying Mr. Omond in his visit to the various instruments; inspecting the Observatory and its interesting contents, and the new turret erected to overtop the snows of winter which bury the house itself; sending off messages to our distant friends, and partaking of an early breakfast—we parted with our kindly hosts with heartiest thanks and loud parting cheers. The wooden hotel on the summit, crowded with visitors, was silent and shut at our midnight arrival, and as we left, its inmates began to crawl forth in the chill air.

8. The Descent.—In the bright morning, we were able to examine the rocks more carefully than in the dimness of the previous night, and to observe more clearly the surrounding country, with its splendid combinations of sea and land, mountain and glen, moor and stream. The green hollow crest of the vitrified fort of Dundbhairdghall, or Dungardil, on the other side of the Glen, was well seen; as well as the valley beyond it, down which a branch of the Glen Nevis glacier once went, when the ice rose higher than 900 feet, the level of the pass at the fort.

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9. The Drive to Roy Bridge.—Joining our carriages a little after eight o'clock, on Tuesday the 28th, we drove towards Roy Bridge. On the left, we looked down on an old bed of the River Spean, where nestles the farm of Auchindaul, before it cuts its way through the narrow, rocky gorge at High Bridge, on General Wade's old road. To the right, stretched the moory ridge of Unachan, which figures so much in Glen Roy literature, as the remains of a possible dam to the old lake. On the way, we crossed those strange, kaim-like lines of debris which traverse Unachan in succession, and run across the high road, and up the opposite ridge of Meal Dhu ; some of them onwards over the Spean to the slopes of Stron-a-baa, overlooking Loch Lochy. These are doubtless connected with the glaciation of the district, but they have not received sufficient attention in relation to this subject.*

II. GLEN ROY.—*Tuesday, July 28th.*

Having reached our inn at Roy Bridge, secured quarters for the whole company, and substantially breakfasted, we set out for the head of Glen Roy to examine the famous "Roads" or "Parallels," the main object of our journey, which have attracted the study of our foremost geologists, raised more controversy, and created more extensive literature, than perhaps any other single geological problem.

1. The View from Bohuntine Hill.—After catching various glimpses of them, especially when opposite Glen Glaster, we reached the famous point of view on the north side of Bohuntine Hill, above Achavaddy, where the greater part of Glen Roy stretches right before the spectator. There the strange triple lines are seen, traced upon its bare, treeless, grassy sides, with marvellous and indelible distinctness—a sight once seen never to be forgotten, and certainly, of its kind, unsurpassed, if not unique, on the surface of our globe. The Roads remain ever wonderful, even to those who have often seen them. They are much less distinct in the *mid-day* light than at morning or evening, when the slanting rays, deepening the shadows, greatly increase their clearness. While the party were seated there, gazing on the impressive scene, the author gave an exposition of the character of the Roads,

* A paper on these lines appears in the *Transactions* of the Inverness Field Club, Vol. I., by Mr. Colin Livingstone, of Fort-William.

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the conditions of the problem, and the various theories propounded to explain them, in the lines of the exposition given in May last.*

2. THE HEAD OF THE GLEN.—This finished, we continued our journey to the head of the Glen, at the junction of the Turret and the Roy. From the central flat plain of gravelly debris, between these rivers, the level of which is a little below that of the lowest "Parallel," you have the whole of the Roads exhibited round you on every side, more distinctly than at any other point. On Carn Dearg (Jamieson's "Tom Brahn"), situated between the Turret and the Roy, they are remarkably clear, being the best in all these Glens, especially just above Lechroy, where they are as broad and plain as a railway embankment. These were, however, too distant to be reached in the time. Some of us climbed to No. IV. (as the lowest Road is known in the literature of the subject), at a part distinct when viewed at a distance, but difficult to make out on the hillside when reached—a common experience where the slope is not steep, and where the Road blends more or less with the face of the hill.

The upper reaches of Glen Roy are here well seen, where Nos. IV. and III. unite from opposite sides of the valley; while No. II. or the highest, disappears through the col that leads over the watershed to Lochan Spey, a few miles off, the head waters of that river. This col formed the outlet of the Glen Roy lake when it stood at its highest level, which thus discharged its waters into the German Ocean by Strathspey.

Through this pass also, and down Strathspey, flowed the great stream of ice that filled Glen Roy during the Glacial Period; but, prior to the formation of these Roads, when Glen Roy formed one outflow to the immense accumulation of glacier ice that blocked Glen Spean. This is a passage for the ice at first sight unexpected and surprising; but it is incontestably proved by the striations, *roches moutonnées*, and their well-marked stoss and lee sides, at the head of Glen Roy—as acknowledged by Jamieson and other observers, and examined and marked in detail by myself.

In the opposite direction, towards the S.W., you look through another pass, drained by a small stream called Alt a' Chomblain,† the summit level of which is 1,172 feet. Through this came the overflow of the lake that filled Glen Gluoy. There a similar

* See the substance of this exposition in the present volume, p. 40.

† Wrongly called Glen Turrit in Jamieson's Map.

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Road exists, known from its height as No. I., 1,173 feet; as well as traces of others at lower levels, but all higher than the highest in Glen Roy (No. II.),which stands at an average of 1,148 feet; No. III. being 81 feet and No. IV. 212 feet lower still. Glen Gluoy lake thus formed a tributary to that of Glen Roy, being dammed back by a sufficient barrier at its mouth, opposite Loch Arkaig. Through this pass came also the ice stream that was forced up Glen Gluoy, and out into Glen Roy before the Glen Gluoy lake was formed.*

Had the vigour of the party not been largely drained by the sleepless night on Ben Nevis, much more would have been done and seen at this most interesting centre of observation and inquiry; for many phenomena there exhibited claim careful examination, and have not received the attention they deserve even from writers on the subject.

3. The Return Journey showed the Roads with greater distinctness in the evening shadows, especially on the steep sides of Ben Iaruinn. The curving round of Nos. II. and III. into and through "the Gap" above Achavaddy, between Bohuntine Hill and Leana More, was well seen. The deep debris which clothes the whole of the mountains of Lochaber, and especially of Glen Roy, upon which the Roads have been impressed, was well exhibited in numerous sections cut through by the rapid and powerful streams that descend the steep sides of the Glen and cross the high road we traversed. The abundant fine gravelly deposits that have accumulated between Bohuntine Hill and Meall Dhu, above Cranachan, below the level of No. IV.—deposits in the bottom of the ancient Glen Roy lake—also claimed attention. The sudden termination of the "Parallels" at points symmetrically opposite each other on both sides of the Glen, without any cause apparent to the eye, such as heaped debris, was remarked as an important item requiring explanation in any theory advanced for their solution.

A comfortable meal and the profound sleep of the weary and the just ended our first double day's delightful experiences.

* See present vol., p. 46.

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III.—GLEN SPEAN AND LOCH TREIG.—
Wednesday, July 29th.

1. The Valley of the Spean.—Next morning, accompanied by more of our Edinburgh friends who had arrived the night before, we set out to examine the upper parts of Glen Spean and its tributary streams. The lowest "Parallel," No. IV., extends up this strath as far as Loch Laggan. This lake is, in truth, an existing representative of the ancient lake that had carved these lines on the mountain sides! The two higher "Parallels" terminate at the mouth of Glen Roy itself, on both sides of Bohuntine Hill and on the mountains opposite.

The morning was bright, the scenery splendid, and our spirits were correspondingly elevated. No. IV. was at once distinctly visible on the opposite side of the valley, running along the steep face of Ben Chlinaig and extending seawards to its own termination at Corrie Choilzie. It soon appeared with great clearness on the north side of the glen, on the front of Craig Dhu, round which it sweeps into Glen Roy, and it curved up the strath before us to the left on to the summit level at Roughburn.

2. Chambers' Other "Parallels."— Other lines were observed both above and below No. IV., especially on Craig Dhu. These were interesting as being those on which Robert Chambers based his argument, in the "Ancient Sea Margins," in favour of the marine origin of the "Parallels." His reasoning may be thus put:—Lines the same in kind with the so-called "Parallels" incontestibly exist both above and below the "Parallels," down to the lower levels, as well as abundant gravelly deposits in the bottom of the glen, which can be proved to be laid down by the sea. Similar lines are found all over the country, which he contended are all "ancient sea margins," and which he laboriously catalogued. If these numerous other lines are laid down by the sea, the similar "Parallels" of Lochaber have been formed in the same manner. These are, therefore, simply very distinct sea beaches.

The argument was ingenious and looked logical. It seemed to be supported by a mass of wide-spread evidence, which required a large volume to detail it. It would have been conclusive, if the *similarity in kind* between the "Parallels" and the other lines in Lochaber and elsewhere, on which the whole arrangement rested, had been borne out by facts. But, unfortunately, the other lines in

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Lochaber, so carefully registered by Chambers, are found, on examination, to differ entirely from the "Parallels" in outline, formation, breadth, relation to the mountain sides, extent, and other characteristics. They were, therefore, produced by entirely different causes, as the author endeavoured to prove in a paper read before the Edinburgh Geological Society on the 17th of April, 1873, which appears in abstract in the *Transactions*.* There it is contended that these other lines are lateral moraines, marking the successive boundaries of the glacial ice that filled Glen Spean, an opinion briefly indicated by Jamieson: whereas the famous "Parallels," according to most observers, are proved, by outline, slope, equality of breadth, composition, and otherwise, to be deposited by water; while certain lower stratified terraces in Glen Spean, on the other hand, are admittedly laid down or re-sorted by the waters of sea, or lake, or both. This lower-terraced detritus is seen abundantly exhibited all along the bottom of Glen Spean, and in striking amount near Murlaggan.

The existence of a series of former lakes along the Spean was evidenced at different levels, especially on the flat above the rocky barrier that forms the falls of the Spean, called Eas na Smuid, or the Fall of Smoke, near Spean Lodge. Here the waters of the Spean must have been barred back into a lake, before they cut the difficult track through the present narrow rocky canal that exists at the falls. A similar lake evidently existed above this, opposite Tulloch. The presence of such lakes is noted by Milne Home in his valuable and elaborate papers on Glen Roy, in the *Transactions* of the Edinburgh Royal Society for 1846 and 1847. The character of both classes of lines, which Chambers thus failed to discriminate (viz., the "Parallels" and the ridgy moraines), and their relations to each other, are very well shown on the front of Craig Choinnichte, which is the eastern continuation of Craig Dhu, opposite Tulloch and Inverlaire. There they are mingled together, and can be easily examined a short distance above the highway; both lines running on more or less continuously, but very different in character, along the face of Craig Dhu.

3. Glacial Phenomena in Glen Spean.—The carried blocks, which are so numerous in this valley, especially on Craig Dhu,

* "Notes on the Glaciers of Glen Spean and their relations to Glen Roy." See also fuller quotations from the paper in Milne Home's paper in *Trans. of Royal Soc. Edin.*, vol. xxvii., 1876.

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were also noted, up to its peaked summit, 2,161 feet. Clach Mhor, or the Big Stone, which consists of grey syenite, weighs 40 tons, and stands only a little below its top, was distinctly visible on the sky line; its original site, as well as that of the numerous granite blocks scattered over this and other hills, being still undetermined.*

Glaciated rock surfaces were examined at various points on the floor of Glen Spean, where they are exceedingly well exhibited all along the valley, from Glen Roy on by Loch Laggan to Kingussie. We drove to the rocky projection on the road, just west of Roughburn, where it overhangs the Spean. There occur the best ice scratches along the whole route. These are beautifully, and it is to be hoped imperishably, traced on the fine-grained grey syenite, so largely developed opposite Loch Treig.

In the lower parts of Glen Spean, the scratches run parallel to the general trend of the valley; in the upper, they gradually begin to curve southwards towards the mouth of Loch Treig; opposite it, they point directly southwards into its opening; beyond that, they curve towards the N.E., still, however, pointing towards Loch Treig; till at length they once more run parallel to the line of Loch Laggan. Along its shores, at various places, they are finely shown, especially at the roadside beyond Moy, near the painter Ansdell's house. These parallel directions and systematic deflections from the main run of the valley of the Spean, combined with other considerations too long here to state, seem decidedly to prove the existence of a glacier protruding from the close mountainous glen of Loch Treig, fed, as it would be, by an extensive ice-generating area at the back of the Nevis mountains. Such is the opinion of Jamieson and most other observers, except Milne Home. Filled with growing opposition to local glaciation, and an admiration of his great North-West Arctic current, with its floating and scratching bergs, he contends that the glaciation of the Spean was made by floating ice borne *upwards* along the valley from the west. In this contention, so far as I am aware, he stands quite alone. But this is not the place to enter into the polemics of the subject, in which a single redoubtable champion

* For notes on these blocks, see the Reports of the Boulder Committee of the Edinburgh Royal Society, of which Milne Home was the indefatigable convener.

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stands undismayed on the one side, against a host, not less fearless and firm, on the other.*

4. The Great Horse-shoe Moraines of the Treig Glacier.—We ascended to the top of the syenite ridge above Roughburn, which is the centre of the broad undulating plain into which Glen Spean there widens, five miles in breadth from Loch Treig across to Ben a'Mheirlich on the north side of the strath. The view from this point was expansive and magnificent, unsurpassed of its kind in the country. Before us stretched the splendid series of giant peaks, most of them over 3,000 feet, from Ben Alder to Ben Nevis—at once the highest, wildest, and grandest in Britain. Right in front of us, the range was deeply and sharply cleft in twain by a steep, narrow gorge, in which lies embosomed the dark and deep Loch Treig, whose waters were seen gleaming in the morning sun; this loch being one of the finest and most picturesque of our wilder and more secluded mountain lakes.† Running straight into the mouth of Loch Treig, the lowest "Parallel" was beautifully seen impressed upon the hills on both sides, a little above the surface of the water. Below us, across the Spean, expanded the great moory undulating flat, called Sliabh Lorgach.

Extending from the left side of the mouth of Loch Treig, a series of ridgy lines was distinctly traceable at a height of near 1,500 feet, nearly half way up the face of Garbh Beinn, which forms the eastern wall of Glen Treig. These ran onwards to Craig Dhu of Fersit, curved continuously in successive ramparts across Sliabh Lorgach on to Roughburn, where they passed the Spean at 800 feet, and swept round to the north, behind us, uninterruptedly onwards to the front of lower Craig Dhu, where they united again with the lowest "Parallel."

These ridges form what most glacialists who have examined them consider to be the successive moraine boundaries of the great glacier which here projected across the valley of the Spean from the basin of Loch Treig. These were first brought under notice by Jamieson in his well-known paper on Glen Roy, published in

* See Milne Home's papers on Glen Roy in *Transactions of Edin. Royal Soc.* for 1876 and 1877, and the Reports of their Boulder Committee.

† See this view admirably rendered by Captain White in Sir Henry James's "Parallel Roads of Lochaber," published by the Ordnance Survey, as well as other views in Glen Roy and Glen Spean—a book worth possessing for these views alone.

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1863, and were more fully described by the author in the paper already mentioned on "The Glaciers of Glen Spean," read in 1873; in another paper read before the Inverness Field Club in 1880*; and again in 1885 before the Edinburgh and Glasgow Geological Societies, which led to the excursion now described. The author is now engaged on a full treatment of them in a paper which he hopes soon to read before the Royal Society of Edinburgh on the "Glaciation of the Nevis Mountains."

On the other hand, Milne Home firmly holds that they are not moraines at all, but the kaims of "submarine detritus, which have been scoured out into long banks by the action of sea currents." He nevertheless acknowledges "that they deserve much more examination" than he had the power of giving. He is also obliged to concede that "a small glacier existed in Glen Treig, and that it even probably protruded a little way into the valley." †

Into this controversy we cannot here enter. I simply express my belief, after nearly twenty years of examination, that they are the moraines left during the last stages of the glacier of the Treig, before it shrunk back into the mouth of the deep hollow of Glen Treig, and thus allowed the waters of the lowest Road to stretch on to the pass of Makoul at the eastern extremity of Loch Laggan. There they had their outlet, and so ran eastwards down Strathspey into the German Ocean, into which the waters of the three ancient Lochaber lakes all flowed.

In order to examine these curving ridges and see the whole from the best point of vantage, we ascended to the end of Craig Choinnichte. There they impinge on its eastern slopes, and continue along the front of Craig Dhu, some distance above No. IV. "Parallel." From this elevation, the moraines presented a splendid appearance, sweeping round from the mouth of Glen Treig, across Sliabh Lorgach, over the Spean, and onwards to where we stood, in magnificent curves, some four miles in diameter; and they greatly impressed our party. They consist of several concentric lines, two of which are more or less continuous, the outmost lines being fragmentary. The outer of the two great and more distinct circles has a general resemblance to a kaim, being composed of debris of varying roughness, embodying blocks of different

* See the *Transactions* of the Club, Vol. I.; *Nature* for May 20, 1880; and the present Vol., p. 40.

† See the tenth and last Report of the Boulder Committee, p. 151.

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sizes, and having an undulating outline. The inner circle consists of a *traineé* of blocks of all sizes, chiefly of grey syenite. These ridges vary in height from 10 to 30 feet, and their composition is easily examined at the place where we stood, at which the outer and inner greater circles unite. Inside these curves, numberless blocks are scattered about, of all sizes, from mere stones to rocks, many of which are thirty feet high.

On the way to our carriages, we crossed "Parallel" No. IV. East of Craig Choinnichte it exists only at intervals on the north side of Strath Spean, and is there determined with difficulty. Indeed so great is this difficulty amid the broken debris and scattered blocks that cover the surface, that it is impossible categorically to assert of the different flats there exhibited that any one of them at special points is or is not the "Parallel," beyond a general coincidence of height at several places.

One point in particular was specially sought for by Mr. Melvin, of the Edinburgh Society, where, on the Ordnance map, a sudden change of twenty feet in the level of the "Parallel" is shown! This spot we found after considerable search, and the conclusion was forced on me that, under the peculiar difficulty or impossibility of accurate determination, it was undesirable, at this portion of the valley, categorically to put down the "Parallel" at all. This caution is all the more necessary where the "Parallel" seems to show such an extraordinary change of level at the top and bottom of a rocky hammock. Surely, no argument can, in the circumstances, be rightly based on any such variations of height as are here exhibited on the Ordnance map.

5. THE MOUTH OF LOCH TREIG.—We now drove across the Spean and the Laire to Inverlaire House, where, scattered at ease on a grassy slope, under umbrageous fir-trees, we had our Spartan lunch, supplemented by abundance of excellent milk from the farm and the coolest and clearest of water from a neighbouring spring—the water being qualified by some members, and all the viands seasoned with appetite. Thence we proceeded to the entrance of Loch Treig, where we traversed the mountain side for some hours.

The narrow mouth of this loch is extraordinarily glaciated; in fact, it exhibits the strongest evidences of intense glaciation in this country with which I am acquainted: and I have seen the best of those in the Highlands. On its west side, above the stepping-

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stones at the extremity of the lake, the rocks in the narrow pass show not only beautiful polishings and striæ, made by the ice on its *under* surface, but also others formed by *lateral* pressure; and, at one place, the results of *upward squeezing* on overhanging rock, which has been ground into the finest curves. Time prevented our visiting this last interesting example, but many others sufficiently striking were seen. This glaciation reaches up on both sides of the pass to some 2,000 feet above the lake.

We climbed to a projecting rock which commanded a view of the whole of Loch Treig on both shores, with its steep banks and enclosing mountains. As seen from the other side of Glen Spean, and easily at the mouth of Loch Treig itself, "Parallel" No. IV. enters some distance *into the mouth of Glen Treig.* It is, therefore, a very important point to determine *how far up Loch Treig it goes,* whether it sweeps round the whole of Loch Treig or terminates at some place within its hollow. That it runs round Loch Treig to its head is maintained by Milne Home, who figures it as going round the whole lake in all his maps, and who now stands alone in asserting its existence round the whole lake, though it had been previously suggested by Dick Lauder. Our party gave the most careful examination to the banks of the loch, and inspected it on both sides of its mouth. Including Mr. Livingston, of Fort-William, who knows the ground as well as, if not better than, any man, we *came to the unanimous conclusion that no evidence whatever is shown for the existence of this "Parallel" round Loch Treig; but that it ceases suddenly and symmetrically on both sides of its mouth at a point inside of the stepping-stones,* as laid down in the Ordnance Survey.

For years, I have myself examined the place from every point of view, (having stayed repeatedly at Fersit, near the spot, and having travelled the lake from end to end,) and again and again more particularly after the publication of Milne Home's opinion; and I have never seen the least grounds for the assertion that the "Parallel" runs rounds Loch Treig. On the other hand, I am prepared categorically to give it a direct denial.

This negative decision on this point has the most important bearing on the various theories adduced to explain the "Parallels." It pronounces strongly against both the marine and the detrital dam theories, according to which the lowest "Parallel" ought to enclose Loch Treig. But it is a strong and striking fact in support

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of the glacial theory. In my opinion, it forms one of the best arguments in its favour, though it has not yet been adduced by writers on the subject. I hold that No. IV. was dammed back at the point in the mouth of Glen Treig, where it ceases, by the Treig glacier when it had shrunk back entirely out of Glen Spean; that this glacier occupied the deep hollow of Loch Treig during the whole period of the existence of the lowest Lochaber lake; and that the existing blockage to the lake at the stepping-stones is, in all probability, part of the terminal moraine, which marked its then existing boundary. This blockage runs like a steep, narrow bar between the loch itself and a lower pool, and descends rapidly into the deep water on both sides, especially on the upper, where Loch Treig suddenly deepens; and over it the waters of the loch gently ripple in so shallow a stream that stepping-stones have been placed in the current.

6. The Moraines above Fersit.—We crossed the Treig, which was lower than I had ever seen it, at these stepping-stones; while a young Hercules of our party waded the river with an elderly member borne Atlas-like upon his broad shoulders, amidst the plaudits of the party and the echoes of the hills.

The glaciation on this side, on the northern slopes of Garbh Bheinne (the Rough Ben), which bounds Loch Treig on the east, is unusually strong and fine, and is found up to some 2,000 feet. It is, of course, much better the lower down it occurs, on account of the greater pressure of superincumbent ice. It is exhibited in splendidly rounded *roches moutonnées*, with the lee or rough side looking *away from* the loch, in smoothings and polishings, in long, well-rubbed groovings and flutings, and in scratches and lines down to the most delicate striæ; for the rocks here preserve the whole with uncommon crispness and permanence. The contrast was remarkable between the general aspect and outline of the rocks as viewed from above, next the loch, where they were beautifully curved and rounded like the sleek flanks of a racehorse, and as looked at from below, where they were ragged and precipitous—a good illustration of the two sides of the famous shield, as well as a striking proof of the passage of the icy stream outwards into Glen Spean. It was the unanimous opinion of the party, that, as a whole, they had seen nothing equal to the glacial phenomena so abundantly and powerfully shown at this pass of the Treig.

It was also specially noted that the striæ, scratchings, and

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flutings gradually curved or rayed outwards from the narrow pass, as the ice itself must necessarily have done, when, after being released from the confined bounds within, it spread over the broad strath in front,—a fact specially noted by Agassiz and Jamieson.

Rising along the slopes of the hill above Fersit, we soon came to the ridgy mounds of the moraines we had observed from the far side of the strath. Four of these are well marked above Fersit, though they increase in number to the east. They are put down by Milne Home at 1,120, 1,165, 1,175, and 1,480 feet above the sea—that is, from 500 to 900 feet above the Spean. The highest, however, is considerably above the 1,500 feet contour as laid down on the Ordnance Survey and as observed by myself—that is, over 1,000 feet above the valley at the junction of the Spean and the Treig. We followed the best marked ridge, which runs along the hill face and is separated from it on both sides, being laid down there like a huge embankment roughly prepared for a railway. In some places, it is 30 or 40 feet high, even on the upper side, and 40 to 100 feet wide. It consists of rough sandy, gravelly and earthy detritus, with embedded stones and boulders, many of the blocks being large. These ridges gradually near each other, and for a short distance coalesce, under the steep front of Craig Dhu; and then separate again to still greater distances, when the coercion of the hill allowed the ice to expand on the flat plain of Sliaber Lorgach beneath.

From this Craig Dhu one of the finest views of the great Horse Shoe Moraine curves can be obtained, seated as you there are, at the exact diagonal distance from the other point of sight on Craig Choinnichte, four miles off, in a bee, or rather in an eagle, line. Here you look down with ease on the gigantic circles which unite under your feet and sweep so splendidly across the rough moor below. Here also the older, outer, less defined, and less continuous curves may be observed resting on Meallan Odhar and Meall Liath to the east, and Meall Clachach across the Spean; while the whole plain is covered, in wild confusion, with a thousand boulders. The varied character of the curving lines may also be well observed from this point, and their occasional uniting and separating, as shown on the Ordnance map—with the kaim-like character of some of them, as consisting of finer debris, and the trainées of grey blocks that form others. The whole phenomena present a striking and uncommon sight, which enables the beholder vividly to realize

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the glacial past, during which the wide strath was filled with the gleaming *mer-de-glace* of the Treig, as it lay enclosed by its heaped moraines.

The scenery, moreover, is a worthy framework for such a picture, stretching onwards to the serrated peaks of Arasaig and Moidart, in the long-drawn distance down the Spean. Our party were inclined to agree with Jamieson, when he says that "these moraines, together with the ice-worn gorge, afford about as good evidence of the former existence of the Glen Treig glacier as a fossil skeleton does of the former existence of the living animal." *

7. THE BLOCKS OF SLIABH LORGACH.—Descending the hill, we reached the drove-road to Rannoch, and followed it back to Fersit and our carriages. On the way, we were moving through part of the multitudinous blocks we had seen from above, some of them gigantic, grouped and piled in the wildest style. They consist mostly of grey syenitic granite, mixed with masses of porphyry, chiefly red, with schist and gneiss, the proportion of the last to the granite being very small.

This syenite occurs here *in situ* over the whole floor of the valley to the east of the Treig and across the Spean above Roughburn. It forms a special point in Jamieson's paper; but it is there imperfectly mapped, as he was unable to determine its S.E. boundary. This I have since done, and shall describe in my forthcoming paper before the Royal Society. It extends some miles to the S.E., and includes Craig Dhu and Cnoc Dearg up to 3,000 feet. It is assuredly the source of a large part of the granite blocks so abundant in Glen Spean. It seems certain that, on the other hand, many of these came also from the head of Loch Treig and neighbouring valleys; and that the more elevated ones, such as those on western Craig Dhu, came from sources as yet unknown, probably from the westwards. Jamieson seeks too much to draw them from the narrow bounds of Sliabh Lorgach, the plain below Craig Dhu of Fersit.

Along the drove road, the bare rock *in situ* is exhibited, finely scratched and polished, especially in places recently exposed which I had not seen before; for the granite surface, wasting rapidly away, speedily obliterates them.

Where the road crosses the Alt Chaorach, or the Sheep Burn, our weary travellers refreshed themselves by one and all "paidlin' in

* "Parallel Roads," *Q. J. G. S.* 1863. P. 249.

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the burn." Thus employed, they presented a picturesque and happy group, which will ever afterwards be recalled when they hear or sing Scotland's immortal song of friendship.

Soon we were bowling along Strath Spean in the evening light, while the western sky glowed before us over the distant hills. After due refreshment, fairly earned by the long but charming day's labours, we were soon sunk once more in grateful and renovating oblivion.

IV. UNACHAN AND CORRY 'N EOIN.—

Thursday, July 30th.

1. The Mountain Chain of Nevis.—The following day, bright and pleasant as before, was devoted to an examination of the inferior endings of the lowest "Parallel" down the Spean, and of the great Corry 'n Eoin, the Corry of the Bird, that is the Eagle. Out of this corry came one of the largest lateral glaciers which helped to block the ancient lake at its lower termination, according to the glacial hypothesis, and which figures so great in Jamieson's famous paper.

We drove to Spean Bridge, and then across the broad-backed ridge of Unachan, to the farm of Lianachan, where we left our carriages and took to the hill. On the way, we obtained splendid views of the great mountain screen of the Nevis range, right opposite, and of the glens that contributed their ice to that of the Spean; especially the Larig Leacan, along which passes the great drove road to Rannoch and the south, by the head of Loch Treig. This glen shows intense glaciation to a great height, and through it (for its summit level is only 1,650 feet) passed part of the vast accumulation of ice that gathered at the back of the Nevis mountains and forced outlets to itself in this direction by the Treig, the Laire, and the Larig.

2. The Ridge of Unachan, as it is called in several papers, whose real name is the Mointeach Dhubhe or the Black Peat Bog, lies between the old course of the Spean along which the high-road to Fort-William runs, and a still older course of the same river, through the hollow valley close to the mountains, which is now drained by tributaries of the Loin and the Lundy. Unachan seems to be a great rounded *roche moutonnée*, with a central rocky core, covered with glacial debris, which is hidden by deep

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peat and moss. Across it run diagonally the long kaim-like lines described in Mr. Livingston's paper, as already noted. It is supposed by Jamieson to be the remains of the moraine matter laid down by the glaciers that here dammed back No. IV.; and by Milne Home to be the remains of his huge detrital dam, which did the same work. It is so swaddled in peat, however, that its real structure cannot well be ascertained. At the summit of the ridge, a wide-spreading view on all sides is obtained of the surrounding country up Glen Spean and Glen Roy, the parts already examined by us, and over to Loch Lochy and Loch Arkaig in Glenmore. The termination of No. IV. on the north side of the Spean, above Blarour, was well observed; its line, after coming out of Glen Collarig, running continuously along the front of Meall nan Luath and ending suddenly, without further sign, to the east of the Blarour burn, at a point marked by a small tree.

3. The Termination of the Lowest Road at Corry Choilzie.—Farther over, at the other side of the Unachan ridge, we looked down on the hollow valley of Lianachan, an old course of the Spean, already mentioned, and into the mouths of Corry Choilzie and Corry 'n Eoin; and we had the whole Nevis range open before us.

The determination of the point where No. IV. ends on this side drew our attention, as this has been a matter of dispute. The "Parallel" was easily observed running along the front of Ben Bahn, which rises between Larig Leacan and Corry Choilzie. There it seemed as suddenly to terminate as its companion "Parallel" on the north side above the farm of Corry Choilze to the east of the entrance of the Corry itself; and there it is made to terminate in the Ordnance and most other maps. But Milne Home, the great dissenter on this subject, again following Dick Lauder, maintains that evidences of it exist to the west of this point, in the mouth of Corry 'n Eoin itself; though he allows, with Lauder, "that the traces of the shelf here are faint,"* and admits that it does not appear on the hill between Corry Choilzie and Corry 'n Eoin. His desire to find the "Parallel" in Corry 'n Eoin is most natural, for Jamieson unguardedly admits that he "should have considered it a good objection to Agassiz's theory had any of the "parallel roads existed in this gully."† I consider this admission

* See his second paper of 1877, p. 100.

† See his paper of 1863, p. 246.

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to be unnecessary and unfortunate; but this is not the place to discuss the subject. Our party, with one exception, were of opinion that no evidence of the existence of the "Parallel" can be seen beyond the point laid down by the Ordnance Survey. One member thought it possible that certain patches at the hollow where the river issues from the glen might be at the same level as No. IV., but that it would be difficult to assert that they were part of the "Parallel." I have myself, in some lights, thought I discerned slight traces of a level at or about the same height as No. IV. in the mouth of the corry at the Cour; but I am strongly of opinion that no decided statement can be made in favour of the existence of No. IV. beyond the usual ending assigned to it, above the farm of Corry Choilzie. West of the Cour, not even Milne Home maintains its presence. But the discussion of this point and its relations to the glaciation and the "Parallels" must be reserved.

4. Corry 'n Eoin.—This is a profound rocky glen lying between the great mountain of the Aonach, most of which is about 4,000 feet, one of the highest in the range, and Ben an Socaich, which separates it from Corry Choilzie. Its sides are precipitous and bare all round, and in grandeur it is not surpassed by Corry Lees or Glen Nevis, which enclose the great Ben. It is much shorter than these glens, being in truth a corry, as it is named, more than a glen. Its head is as high and steep as its sides and possesses no col, its lowest notch not descending below 2,400 feet. It is drained by a stream called the Cour, which, fed by numerous tributaries, soon becomes a considerable river. It is eminently worthy of a visit, for its scenery and for its splendid glaciation, which has been intense and reaches up its sides above 2,000 feet.

Accompanied by a young and stalwart Highlander, and shortly joined by his father, the head keeper, we ascended right into the glen by the high ground to the west of the Cour. We passed some bare rocks covered with grooves and scratches. These were unusually long and deep, and ran parallel to the Corry and at right angles to the Spean. Time prevented our seeing some still finer, which are the best I have seen in these mountains, and are not surpassed in the country.

In the middle of the Corry rises an eminence called An Guirean, which is a peaked boss of rock, steep on all sides, and mostly bare. It is, in fact, a huge *roche moutonnée* which has been swathed in the ice sheet that filled the glen, set in its very centre as if to prove

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its depth and power. It is rubbed, scratched, and smoothed all over, especially on its upper face and head, though the rocks that compose it have not preserved the finer scratches and grooves like others below. The contrast between its stoss or upper side and its lee or lower side is remarkable; the upper being rubbed and rounded, and the lower showing an untouched rugged front. We climbed to its summit, which commanded a wonderful view on all sides. Above we gazed into a profound hollow corry pot, formed by the scarred precipices of the Aonach and its companion peaks. This was first the steep cradle of the old glacier; and afterwards the bed of a lake now drained. This formed a wildly grand and impressive solitude. On the other side, we had glimpses of the outer world across Glen Spean, and away beyond the Great Glen to the mountains at the head of Loch Arkaig.

5. The Lake Dams Required.—From the heights at the entrance of Corry 'n Eoin, a vivid conception is gained regarding the barrier which held back the waters of the great double-breeched lake that formed the lowest "Parallel," with its long limbs stretching upwards into the far ends of Glen Roy and Loch Laggan.

The demand of a detritus dam between Corry Choilzie and Blarour is seen in all its magnitude. We are asked to believe that such a dam filled the strath below, from side to side, and held back such a lake. This dam would require to be four miles in length; at least 500 feet in height above the nearer valley of the Cour, and 600 feet at the Spean; and miles in breadth to withstand the hydrostatic pressure of so great a mass of water. It is also asked that this immense mass of debris shall be placed here where there is no apparent or adducible reason for its existence. Further, we must concede that it has vanished or somehow been removed, and left not a trace of the mighty embankment, except the ridge of Unachan and the low gravel deposits of Glen Spean. It is a large demand on faith and a heavy burden on reason; at least, so thought and said the party that then looked across Glen Spean.

On the other hand, the magnitude of the glacier dam that is required for the work assigned it, is also strongly exhibited from such a position, and the need shown of possessing correct conceptions regarding it, if this theory is to be finally accepted. These can only be obtained by a careful and detailed study of the glaciation of the whole district in question; and nothing has impressed

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me more than, on the one side, the imperfect presentation of the glacial theory by its advocates, and not less by Jamieson, its best and most logical expounder; and, on the other, the manner in which it has been misunderstood, especially by Milne Home, its chief opponent, and even by Professor Prestwich—all from deficient knowledge of this general glaciation.

On the one hand, I agree, with Professor Prestwich and Milne Home, that alone "the Glen Treig glacier would be incompetent to the task assigned to it" by Jamieson; and that Jamieson's summary of the subject is inadequate when he says—"Grant two ice streams, one in the Great Caledonian Valley (taken in conjunction, as he explains, with the Corry 'n Eoin glacier) and the other at Loch Treig, and the problem of the 'parallel roads' can be solved." On the other hand, Prestwich's criticism is based on an imperfect presentation of the glacial theory; and Milne Holme's is all through an unconscious but unintentional travestie. Thus writes Milne Home—"It seems really almost impossible to believe that a glacier formed in any of these Lochaber corries should have produced tongues of ice more than twice as long as the glaciers themselves, and that these tongues should, at their tips, have formed permanent ice barriers." "Mr. Jamieson," he continues, "brings together, to form his ice barrier for shelf IV., no less than three tongues—one from Corry 'n Eoin, one from Arkaig, and one from the Great Glen. The meeting of these three ice-tongues, coming from opposite directions, would be a very remarkable conjunction indeed if it had the effect of producing a solid barrier of ice." No doubt it would, if they were asked to do it; or if they were all the ice available for the work. And he triumphantly asks, "How is it possible to suppose that merely the tongue of a glacier from the Treig valley—a tongue wending its way across valleys and round hills for five or six miles could dam a lake such as that which filled Glen Roy?"* Milne Home's tongue has run away with him in such a description of the theory he opposes. I am bound, however, to admit that my good friend and leader, Mr. Jamieson, is partly to blame for allowing him no small grounds for his caricature, by giving certain glaciers too much to do, and by not using others equally willing and able to assist in the work.

*See Milne Home's Paper for 1876, p. 629, and the Tenth Report of the Boulder Committee, p. 161.

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6. THE SOURCES OF THE ICE DAM.—Shortly, the case for the ice may be thus stated. Glaciers descended into Glen Spean from the Nevis range, the highest in the country, not only from Glen Treig and Corry 'n Eoin, but down the Laire, through the Larig Pass, and out of Corry Choilzie, Glen Rois, the Glen of the Lundy, Corry Lees, and Glen Nevis—each of these contributing its quota to the general accumulation in Strath Spean. The Spean is, besides, topographically so situated at right angles to all these glens as to receive into its own basin not merely the united contributions of the glens that open into it on that side of the mountain group, *but also the greater portion of the vast glacial ice that concentrated at the other side of the group*, in the Nevis-Rath glens. From their configuration the Nevis-Rath glens were compelled to disgorge the most of their ice *through the mouths of the Treig, the Larig, and the Nevis.* The ice that thus filled Strath Spean was, for these reasons, so great that it even forced a passage for itself at one period out at the head of the Roy, and at the far end of Loch Laggan.

But this is not all. The accumulated ice of the Spean was further augmented, and retarded in its place, by that existing in the Great Glen, gathered there from its large lateral valleys, especially from Glen Arkaig,—ice which, at one time, also pressed its way up Glen Gluoy and out at its head into the Roy. This ice of the Great Glen was yet further added to by powerful glaciers coming partly down Loch Eil and through Glen Loy.

Moreover, the seaward outlet for this immense accumulation of glacial ice was remarkably constricted at the head of Loch Linnhe and down its narrow throat, the only outlet to the outer ocean. Its outward passage was further obstructed by the overflow of ice from Glen Nevis at the vitrified fort of Dunjardil, and by the still stronger mass pressing it at right angles at Ballahulish.

There thus arose an immense, nay extraordinary, congestion of ice in the lower ends of the Great Glen and Glen Spean, such as existed nowhere else in the country, and such as could only exist under such concentrating and constricting geographical conditions. Ice! Instead of too little of it, as loudly complained by Milne Home and others, we have enough and to spare for the work we ask it to do. Nay, its amount is embarrassing and compels the glacialist carefully to consider when and how it acted as the ice dam he claims it to have been; to examine into the portion of the

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glacial period when it did this work, the manner of its retreat, the pauses it made, and its whole relations to the "Parallels."

But this is not the place to enter into these questions. I merely wish here to indicate that there is more ice available for the special function attributed to it than either its friends or its enemies seem to have dreamt of. And these sources of glacial ice are proved, beyond all question, to have existed and coalesced, by a detailed examination of the glaciation of the region. After a delightful lunch at the farm of Lianachan, in full view of these glens and mountains, we drove back to our hotel. This was our last evening together as a whole party, more than half of the members leaving that night for Fort-William or next morning for Kingussie. Before separating, we reviewed the work of those happy days with mutual gratulations and pleasant speech, resolving, if possible, that this should only be the first of similar re-unions in the coming years. Six of us, all belonging to the Glasgow Society, remained behind at Roy Bridge, in order to complete the survey of the wonderful phenomena we had come so far to see.

V. ROUND BOHUNTINE HILL—THE GAP AND GLEN GOLLARIG.

Friday, July 31st.

We drove up Glen Roy to the grand point of view above Achavaddy, climbed through the "Gap," between Bohuntine Hill and Leana More, along "Parallel" No. II., the highest in Glen Roy, and onwards down Glen Collarig, and across the Alt Ionndrain, which drains it, back to the hotel. The weather still smiled on us. The phenomena exhibited were interesting and striking, and the points of discussion numerous and important; so that, altogether, it formed, perhaps, the most instructive day we spent in connection with the problem. It enabled us somewhat to gather the threads we had been spinning during the week into a firmer and more satisfactory clue. It is only a pity the whole party did not help to wind it.

1. The "Parallels" in Glen Roy.—The view of the "Parallels" was the best we had obtained, the morning light and deepened shadows bringing them out in wonderful relief against the hillsides. By their closer inspection as thus seen, and by an examination of the Roads themselves on the spot, we were enabled to come to more definite notions on several points than at our first journey up Glen Roy.

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(1.) We were impressed with *the extreme difficulty of accurately taking the true levels of the Roads at the different parts of their course.* As has already been adverted to, the Roads at many places cannot well be made out when you stand upon them, though their line is well enough seen from a distance. Thus different opinions would be held by different observers as to their exact boundaries both above and below. These difficulties of determination would, of course, give rise to differences of opinion regarding the exact point at which the level of the Roads should be taken at successive places. This accounts, to a great extent, for the varying levels at which they are mapped, even where the Roads are more or less distinctly marked and bounded. Many of the variations in level, and in breadth and slope, as laid down on the Ordnance maps, are easily accounted for, through this dubiety of accurate determination.

(2.) *Other variations on these and other points were also obviously explainable by various local conditions*—such as the slope of the hill face, the character of the debris on which they are impressed, landslips which are pretty numerous and quite distinct, the cutting-through of the Roads by streams, and like facts.

(3.) *Obliterations*, as shown on the maps, *were also seen to be very explicable by various local conditions*—such as the presence of rocks at several places in the Roads, the extreme slope of the hill, landslips, weathering, the passage of torrents, which are often furious on such steep mountains, the absence of debris, the form of beach, etc.

(4.) These and other difficulties showed *the impossibility of mapping these ancient beaches with absolute uniformity and certainty* by even the best Government or other surveyors, however capable. Indeed, the work would require a committee of scientific specialists to accompany the surveyors, in order to determine height, breadth, and slope, and settle the exact point of levelling, all along the "Parallels," so as to have the work done with scientific accuracy. They also showed the caution that is needed in basing any reasoning or theorizing on such necessary variations in the present maps. It was certainly very obvious that too much should not be made of such variations—a tendency to which is shown by Prestwich, perhaps, more than any other writer on the subject. The Ordnance maps are undoubtedly sufficiently accurate for all practical purposes; though it must be confessed the observers might have shown

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more scepticism as to their presence in many places than they seem to have done.

(5.) *The absence of notches or indentations on the hill face along the Roads* was noted. Only one such notch was observed—viz., on the sky line on the right or eastern side of the glen, on the face of Leana Mhor. The general correctness of Macculloch's early observation that *the Roads are laid down on the face of the mountains like a series of superposed parallelograms* was acknowledged.*

(6.) *The contrast of the contour of the Roads to that of moraines, especially those we had seen in these glens, was complete.* The Roads sloped everywhere at a low but varying angle down towards the centre of the valley, and their surface formed a straight line; while the moraines were ridgy, kaim-like, and irregular.

(7.) *The absence of water-worn stones was observed as a feature requiring special explanation* on any water theory, whether of sea or lake. If these terraces represented the shores against which water washed and worked during a more or less lengthened period, why were the stones that formed the beaches not rounded? This is a great difficulty which writers on the subject have not sufficiently considered. At first sight, it seems to be inexplicable on any aqueous theory. In my opinion, it appears to prove that the water that impinged against these beaches was *frozen over the greater part of the year*, and that the Roads were thus protected from the action of wind and wave.

(8.) *The lower termination of No. II., the highest Road in Glen Roy*, has been made a matter of controversy by Milne Home. According to the Ordnance Survey and all observers that have yet written on it, except himself, it ends at the S.W. angle of Meall Dhu, just where it turns round to form the northern side of Glen Glaster. In all his earlier papers, Milne Home agreed with this limit; but in his last, published in 1877, he holds that *it exists on both sides of Glen Glaster, and ends pretty well about the same place as No. III.*, which certainly runs round Glen Glaster. I have examined the glen from all points, especially since his publication of this opinion, and I have been unable to discover its existence beyond the old point generally agreed to; except, occasionally in certain lights, the slightest indications which possibly may or may not be parts of No. II. I was sorry that

* See Macculloch's diagram, often reproduced.

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want of time prevented our party examining this important matter during this excursion, and thus helping in some measure to settle it.

If No. II. does end, as Milne Home asserts, above No. III., his detrital dam is relieved of one heavy burden, viz., the need of having it further up Glen Roy, and then suddenly retreating to where No. III. ends. But in this case also, the glacial theory is equally, if not more, relieved by not requiring the ice dam in Glen Glaster during the existence of the highest Glen Roy lake.

This point requires further observation for final settlement.

2. THE "PARALLELS" IN GLEN COLLARIG.

(1.) We ascended Bohuntine Hill to No. IV., and walked along it to the opening of "the Gap." This "Parallel" does not enter "the Gap," for the summit level of the col which forms it is higher than No. IV.; but the two upper "Parallels," which are higher than the col, run into it on both sides. We climbed to the highest on the south side of the valley, running at a height of 1,155 feet, and went along its well-marked terrace. The Roads here are exceedingly distinct, with clearly defined inner and outer edges and great evenness of breadth. They end quite abruptly, as if suddenly cut off by some barrier which is now quite obliterated. There exists no accumulation of debris, either at their endings or across the glen between these points, to suggest any debris dam. Such a dam, it was felt, could not have been so entirely removed or "annihilated," to use Milne Home's own expression,* as it has been, if it once existed, especially in the immense quantity, both high and broad, that would be necessary to hold back a lake stretching ten miles onwards to the head of Glen Roy.

(2.) All round the Bohuntine Hill we noted fragments of the grey syenite, which is so abundant in Glen Spean, some pieces being above four feet in length. This syenite is also found up to the head of Glen Roy. Large blocks of it can be easily examined on the road side opposite Cranachan farm, where they have been split up for building purposes. Pieces of the reddish porphyry, found also in Glen Spean, are not uncommon all round Bohuntine Hill, but they are much less frequent than the syenite.

3. MILNE HOME'S BLOCKAGE IN GLEN COLLARIG.—The relations of the Roads to each other are perhaps more remarkable in Glen Collarig than at any other place. No. IV., the lowest,

* Memoir of 1876, p. 116.

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does not enter the pass at "the Gap," as already said, but it runs round the south end of Bohuntine Hill and enters Glen Collarig at its mouth. It is seen there on both sides of the valley, and seemingly terminates abruptly at the mouth of the side glen, called Corry Cheirsle. No. II., the highest in Glen Roy, enters "the Gap" above and exists on the hill face on both sides. On the north side, it ends at the corry in the angle whence descend the head waters of the Alt Ionndrian, which drains Glen Collarig. On the south side, it goes farther along on the face of Bohuntine Hill, to a point about two thirds of the distance between its ending on the north side and the termination of No. IV. No. III. also runs into "the Gap" on both sides, and continues farther south than No. II., till about half the above distance, where it disappears symmetrically on both sides.

These varied terminations and relations of the Roads to each other in this glen are made much of by Milne Home in his two papers on the subject. They are, in fact, adduced by him as a crucial test in favour of his theory, and against the glacial theory. He has referred to it frequently since then by way of challenge, as at the meeting of the British Association in Glasgow, and at the meeting of the Edinburgh Geological Society on the 7th of May last, when this excursion was resolved on. For his argument the reader is referred to his papers, and especially to the first, published in 1876, and to the illustrative diagrams. He places a detritus dam right across the valley between the endings of the "Parallels"; for the double purpose of holding back the waters of No. II. and No. III. above, and of No. IV. below.

The subject can only be treated here very shortly, but sufficiently, perhaps, to indicate the line of reply.

(1.) Milne Home holds that a blockage is necessary to dam back No. IV., the lowest Road, at its upper end near Corry Cheirsle. I have frequently examined the valley, especially since the publication of Milne Home's memoirs, and have found that this "Parallel" does not end symmetrically on both sides, but extends farther north on the east side upon Bohuntine Hill; that beyond the point where it seems to end, the bottom of the valley gradually rises to the height of the road and is filled with rough debris; and that this "Parallel" loses itself in this debris till the valley reaches the level of itself at the upper part of the glen, where the Alt-na-Ceardaich joins the Ionndrain. Beyond the apparent

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termination of No. IV., the lake would thus be very shallow, and become, in fact, a rough marsh, ill adapted to form and retain a terrace or "Parallel" at its outer shores.

Similar ill-defined or altogether obliterated endings of the "Parallels" occur at most if not all the upper portions of these glens—at the head of Glen Roy, where No. II. only exists in detached patches; at the col between Glen Gluoy and Glen Roy, where the Gluoy Road No. I., on the one side of the col, and No. II. in Glen Roy, on the other side, gradually die out into indistinctness or nothingness in the debris at the bottom of the valleys; at the head of Glen Glaster, where both No. III. and No. IV. are also indistinct, equally in the valley of the Glaster Burn and at the col between Craig Dhu and Craig Uilleim; and again at the upper end of No. IV., round Loch Laggan, and also before reaching Loch Laggan, at and beyond Roughburn, where it is most fragmentary, and for miles entirely unseen.

This indistinctness or partial or total obliteration at the upper ends of these "Parallels," where the water became shallow at the heads of the glens, seems universal. It is a phenomenon to be naturally expected in the shallows there existing in the waters of the lake.

No blockage is therefore necessary, I contend, for the upper end of No. IV. in Glen Collarig. Such also was the opinion of the party that accompanied me.

(2.) Milne Home's blockage is placed there to hold back No. II., the highest "Parallel," which ought, therefore, to reach down to it *on both sides.* On the north side, unfortunately for him, it terminates at the angle where the Ionndrain descends from the hill, and *not a trace of it is visible between that point and the dam thus laid down.* This is acknowledged by Milne Home himself, who puts it down on his own map as "not traceable." No. II. on Bohuntine Hill also does not come up to his dam, for it stops some distance short of No. III. No. III. alone ends at the blockage for which he contends. So that, on the upper side of his "dam," there are as grave difficulties against it as on the lower, in regard to the terminations of the "Parallels."

(3.) As already said, there is no trace in this part of the glen of such a large accumulation of detritus as would be required to form the formidable dam requisite for such a lake. The narrow dam Milne Home figures would, from an engineer's point of view,

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be quite insufficient for the duty. The hill sides have the same even slope there that they exhibit all along the rest of their course on both sides, and the regularity of slope and face is a marked feature of these Lochaber glens, especially in Glen Roy and its lateral chambers.

Altogether, unless pressed by the irresistible exigencies of a theory, most observers would be safe in saying that no person would assert that such a dam, 1,100 feet at least above the bottom of the valley, ever existed at this part of Glen Collarig.

CONCLUSION.

After crossing the Ionndrain below Corry Cheirsle, we walked along No. IV. into the pastoral hollow of the Bo-loin burn, where the signs of old habitation are seen. Crossing the stream, we ascended the bare and peaty hill called Maol Ruadh, which is the site of a fierce clan battle. There a wonderful view of the whole district we had traversed during the week was obtained, from Fort-William to Loch Laggan and up Glen Roy, and appropriately closed our examination of the world-famous Parallel Roads of Lochaber.

No. VI.—A Glimpse of Skye: with Remarks on Volcanic Action. By James White.

[Read 16th October, 1884.]

Our "stern Scottish Highlands" afford an unrivalled field for the study of physical geology, that very poverty and barrenness which characterize the larger portion of them being due to causes which at the same time constitute their scientific wealth. The extreme irregularity of their surfaces, their lofty mountains, numerous lochs and ravines, and deeply indented seaboard, are all features which add greatly to their value as a field of geological research. Sections are there to be found which we could never otherwise hope to see. The deep glens and abrupt sea-cliffs show the relations of rock to rock, of strata to strata, which cannot be seen elsewhere. Only where it pays by the minerals it yields, can we afford to open up the crust of the earth to see how it is made. We are dependent on Nature to do the rest, and it does it right well in the Highlands.

By what other means could we ever hope to have dissected for

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us a burning mountain? A voyage to the moon is not more impracticable than to descend a volcano to examine and criticise its lurid processes. But here we catch it when it is old and out of vigour, and get beneath, if not behind, its most hidden operations.

A sail across these western seas from Oban to Skye is full of interest to the geologist, and particularly to the student of igneous rocks. Here we pass in succession no fewer than four volcanic centres which, in times so late as the Miocene, have poured out lavas of immense extent, whose scattered and fragmentary condition shows that they are merely a tithe of what they have been. The *Puys*, or old volcanic cones which stud the granitic plateau of Auvergne, in central France, and which are so well preserved that, but for the circumstance that they are cold and quiet, you might take them to be in a state of activity, are referred to the same geological period. The respective states of preservation of the two series are a striking testimony to the destructive effects in these more northern latitudes of the great ice age and the eroding power of the sea.*

Leaving out of view for the present those old Laurentian rocks which mark the outermost border of our country, the principal surface rocks of the region are those Tertiary volcanic rocks which Professor Judd has of late years so ably investigated and described.†

Vulcanicity has played so important a part in the formation and modification of the crust of the globe, that it may be of some interest if we endeavour to place before our minds as concisely and accurately as possible what is really known on the subject.

At present there can be enumerated all over the world, on land and in the sea, about 400 of these volcanic fires in a state of greater or less activity—literally turning the globe inside out. It has always been so; for while active volcanoes can be counted by the hundred, extinct volcanic centres may be reckoned by the thousand; and, however paradoxical it may appear, this is really one of the conditions of a planet capable of supporting life as we know it. A planet that loses the power of internal

* See Prof. Hull, *Jour. Roy. Geol. Soc. of Ireland*, vol. iv., page 30.

† See his admirable papers in the *Quarterly Journal of the Geological Society*, vols. xxx., xxxiv.

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change, as a necessary result loses the power of sustaining living things on its surface. A little consideration will make this plain. Epigene agencies disintegrate the hard rocks and prepare soil whereon plants may grow; these plants become the food of animals; but the soil becomes exhausted and requires to be renewed. Denudation does this, carrying away the effete material to the sea, whilst the frost breaks up the hills to supply more. But it is obvious this cannot go on for ever; without compensating movements from beneath, the system of things would in time become exhausted, and all be reduced to the level of a dead uniformity. But elevatory movements and the volcano step in to play their part and to restore to terrestrial life that material and those irregularities without which it could not exist. And not only are those changes necessary for the continuance of life, they are equally necessary for its development. It is by the ever-changing environment of organic beings that new forms are evolved and the fittest preserved. In vulcanicity, therefore, we have a link in the chain of causes of which we see neither the beginning nor the end, but can see that progress is secured by an ever-increasing adaptation to complex conditions.

When we begin to make some inquiry as to what are the *causes* of volcanic action, we are at once led into an immense arena of speculation and discussion. Let us keep as closely as possible by ascertained facts.

From the testimony of many independent witnesses who have had the good fortune and the temerity to observe it in active operation, it would seem that the behaviour of lava in a volcanic vent, and the method of its ejection, is more akin to that of boiling or ebullition than to anything else that we know. The lava is seen to surge up and down, backwards and forwards, and with a circular motion accompanied by frequent discharges of steam, in a manner precisely similar to any viscous body when subjected to the action of heat. This is a process with which we are familiar; and there seems good reason to conclude that the overflow of lava is due to the same cause, viz., to the expansion of the contained gases, to steam. The question then arises, What is the source of the heat which causes the disturbance? There is (1) the latent heat of the globe, which can be detected and measured the farther we descend into the interior; (2) heat arising from chemical action; or, (3) heat developed

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by mechanical action, viz., friction or crushing. According as one or other of these sources has been regarded as the efficient source, have the various and sometimes opposing theories of volcanic action arisen.

All recent explorers in this department of knowledge have abandoned the idea of chemical action. Whatever may have been the case in the earlier stages of its history, the earth is now too old and settled to admit of anything of that sort. The chemical affinities and repulsions of matter, on anything like the scale required, are believed to be long since satisfied, and nothing is left of this nature sufficient to support volcanic action. The prevailing idea is that it is due in some form or other to the latent or residual heat of the globe, and that the interior of the earth is probably a kind of cavernous, honey-combed structure, containing numerous lakes or reservoirs of molten matter, the invasion of which from time to time by water occasions volcanic action. This structure, it has been argued, would give to the astronomer the rigidity required to account for its behaviour as a planet,* and to the geologist the amount of free material required for its eruptions.

But an eminent writer on this subject—the late Mr. Robert Mallet, F.R.S.—was not satisfied with this explanation, and propounded another, and, as he believed, the true theory of volcanic phenomena, bringing into view the third cause above referred to, viz., mechanical action. He described as a "lame and gratuitous hypothesis" the idea of lakes or isolated masses of fluid-rock existing at different points and different depths, from which volcanic vents are supplied, and returned to the hypothesis of a central hot and liquid nucleus, surrounded by a colder and solid shell. Let me give his definition of his theory in his own words :—

"The heat from which terrestrial volcanic energy is at present derived is produced locally within the solid shell of our globe by transformation of the mechanical work of compression or of crushing of portions of that shell, which compression and crushings are themselves produced by the more rapid contraction, by cooling, of the hotter material of the nucleus beneath that shell, and the consequent more or less free descent of the shell by gravitation, the

* See Sir W. Thomson on "The Internal Condition of the Earth," *Transactions*, vol. vi., p. 38.

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vertical work of which is resolved into tangential pressures and motion within the thickness of the shell." *

The main portions of this theory rest on undoubted facts, which give to it an air of strong probability. Of tangential strains in the crust of the earth, and those of tremendous severity, let the gnarled, crumpled, and contorted schists of these same Highlands bear witness. But unless these rocks had been forced down into a space much less than they originally occupied, they could have had no such compression; and if that which is beneath them were rigid and would not yield, how could they have sunk? And it is obvious that such friction and such crushing must have evolved very great heat. Faulting is always accompanied by abrasion of the rocks, giving rise to heat. Mr. Mallet points out the linear character of volcanic foci, and that they are on lines of weakness in the crust.

But in the midst of our musings our sail comes to an end, and we are landed at Broadford on one of those patches of highly fossiliferous Secondary strata which Hugh Miller described so well, and on the confines of one of those denuded volcanic centres which Professor Judd has brought so vividly before us.

The whole of the northern and greater part of Skye consists of immense sheets of volcanic rocks overlying the Secondary series; and it would be difficult to find a locality where the beautifully-terraced form characteristic of that formation can be more distinctly seen. The hills on every side rise with almost artificial regularity, step by step, to the summit.

The southern portion of the island presents no features which call for special notice, but in the centre there rise two groups of hills which are so strikingly different from each other, and from all others even in this tumultuous land of hills, that they arrest the attention of every passer-by. Those in the foreground from our point of view are the Red Hills, remarkable for their rounded pyramidal forms and red debris-strewn sides, on which vegetation is almost baffled to find a footing. The black and serrated peaks in the background are the "wild, jagged, and fantastic outlines" of the Cuchullins which we saw so well as we left Eigg and crossed over to Arisaig. The Red Hills are masses of granite, the Cuchullins masses of gabbro. The gabbro is younger than

* See an elaborate paper published by Mr. Mallet in the *Philosophical Transactions* for 1873, worthy of a most careful perusal.

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the granite, for numerous veins of it intersect the latter; they are both deep-seated, highly-crystalline intrusive rocks—"plutonic rocks" of the text-books. The strata through which they have been protruded are very much disturbed and metamorphosed, the arenaceous rocks being converted into granitoids and the limestone into marble.

Volcanic rocks are divided roughly into two classes, the one earthy or fragmental, the other glassy or crystalline; the former represented by volcanic ash in its numerous forms, from the finest comminuted dust to the rough and stony agglomerate, the latter by our familiar dolerites, basalts, and pitchstones. A distinction sought to be maintained among the crystalline rocks was between the plutonic and volcanic; this distinction Professor Judd's researches among these "grand old igneous springs," cooled reservoirs of ancient volcanoes, shows to be a purely artificial one; the one being simply the root, the other the stem and branches.* Other observers in other localities describe rocks similar to these gabbro rocks as "Granitones," and trace a connection as unbroken between the basic and the acid series. Mr. Clifton Ward found this to be the case with some of the igneous rocks of the lake district, to which he gave the compound name of "Felsi-dolerites"; so that we can only say with regard to all of them that they consist of matter which has been thoroughly fused, into which water, everywhere present in the earth's crust, has found its way, with the result that by the formation of steam, part of it has been blown to the surface, part injected with great force into the surrounding rocks, the remainder being cooled and crystallized at greater or less depths. All this has doubtless gone on from the earliest stages of our planet's history. The shell cools and solidifies from without; it is constantly being displaced and replaced by matter from within. Thus we come to have, even in these deep-seated eruptive gabbros—these roots of volcanoes—only the extreme of metamorphism after all; the crystalline being the most highly differentiated form which inorganic matter can assume. It is common to speak of the sedimentary rocks as "derivative"; it is just as correct to apply that term to the crystalline.

It is quite a sight to see the glaciation of these wild Cuchullin hills. We Lowlanders with our soil-clad plains can only see these

* See paper in vol. xxx. of the *Quarterly Journal of the Geological Society*, already referred to—a veritable romance of physical geology.

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features on a small scale in stubborn projecting bosses here and there, or in the "tirrings" of quarries; but these hard hypersthene rocks, so utterly innocent of soil or verdure, show it with great distinctness, and on the grandest scale. Forbes, Geikie, Judd, and others have called attention to this remarkable spot.

SPECIMENS SHOWN—

1. Several weathered and fresh specimens of the gabbro of the Cuchullins, and some of the dolerites and basalts into which it passes. These are mostly dykes; but some chips also shown of the overflow lava—one from Portree and two from the Quiraing.

2. Granite from a boss on the shore at Loch Slapin.

3. Weathered specimens with the felstone into which it graduates, from the flanks and top of Ben-na-Cailleach, one of the Red Hills, 2,400 feet.

4. Granite from the lower part of Ben Nevis, and some chips of the over-lying dark porphyritic felstone derived from it.

5. Chips of acid lavas, both vesicular and compact, from the neighbourhood of Oban.

No. VII.—NOTES ON TARBERT, ARGYLLSHIRE. BY JAMES WHITE.

[Read 15th October, 1885.]

THAT quiet little nook Tarbert on Loch Fyne, familiar I have no doubt to many of the members, was to me a *terra incognita*, so I thought I would spend a short holiday there, and with hammer in hand try to pick up some acquaintance with it. In the hope that there may be something to interest others, as I found a good deal to interest myself, I purpose to give some account of what I observed of the rocks round Tarbert.

Among those arbitrary divisions called counties, that of Argyll presents features which are probably unique in Scotland. It has been described as "a congeries of mountains cloven with glens." No part of it is more than twelve miles from the sea. Its outlines are so exceedingly irregular, the projections of mainland into the ocean so bold, its intersections by sea-lochs so numerous and extensive, and the distribution everywhere of land and water so

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intricate, that perhaps no equal extent of country in the world contains so rich and varied a display of landscape.

With an area of 3,255 square miles, its weather-beaten, deeply-indented shores present to the sea a coast line of no fewer than 2,289 miles. It includes eleven arms of the sea, measuring from two or three to thirty-six miles in length, and two of them exceeding in parts the 100-fathom line in depth. There are, besides, numerous valleys which, though now inland and occupied by fresh-water lakes, were evidently at a recent period arms of the sea; and these represent a further line of coast 276 miles in extent. In short, we have here a tract of country which presents features of exceptional interest to a student of physical geology.

The peninsula of Kintyre is the principal of several tongues of land into which this county is broken up, and is about 60 miles in length from where it joins the mainland at Crinan to its most southernly point, "The Mull." The Kintyre district proper, 43 miles in length, terminates at Tarbert. The northern part of the peninsula, between Tarbert and Crinan, is the district of Knapdale, 17 miles long: the average breadth over the whole peninsula is 8½ miles. It is deeply cut into by several sea-lochs, principally on its west side, all of which an elevation of 300 feet would convert into land valleys. It is at the head of one of these small lochs, and on the east side, that our destination lies.

East Loch Tarbert is separated from West Loch Tarbert by a neck of land of no great elevation, and very little more than a mile in breadth. This, nevertheless, forms the watershed between the two lochs, from which burns descend into each of them. This isthmus it has been proposed to cut through, and connect the two lochs by means of a canal, enabling vessels to avoid the circuitous route by "The Mull." A bill for this purpose was passed through Parliament in 1883, but nothing further has yet been accomplished.

The East Loch is scarcely a mile long. At its upper end, next the town, it broadens out into a bay, giving it roughly the outline of a reversed letter L. It is studded with small islets, which give it the intricate and scraggy look it has from Loch Fyne.

The West Loch runs N.E. to S.W., and is 10 miles long, with a mean breadth of three-quarters of a mile. It has an aspect of a totally different character from the East Loch. The rocks on its banks show nothing of that gnarled, scraggy appearance so

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characteristic of the East Loch. It has been described as having the appearance of a fresh-water lake rather than an arm of the sea; "soft and moderately high hills recede from its margin, and woods and enclosures fling their images upon its waters."

The village of East Tarbert seems to be mostly new, and is evidently increasing very rapidly. Herring fishing and the accommodation of strangers are the sole industries. The Fisheries Commission have a station on the north side of the loch, which is under the charge of an esteemed member of this Society, Mr. Scott, late of Greenock.

The rocks in the immediate neighbourhood of Tarbert are of that gnarled, contorted, schistose character with which we are so familiar in the greater part of the Highlands, and notably in that part which has received the grotesque appellation of "Argyll's Bowling Green." They contain numerous lenticular masses and veins of quartz, and sometimes assume quite a chloritic character. They are designated "quartz-schists," from their containing so much of that mineral. They evidently vary much in their composition, and weather out into the most irregular and striking forms. We everywhere see that their gnarled asperities have ante-dated the "great ice-age," and have lived through it; for, whilst it has left upon their contours its unmistakable marks, it has been quite ineffectual to change their aspect.

I had the good fortune to meet in Tarbert Mr. Hill, an officer of the Survey, who had spent some time in examining these rocks, and he informed me that as far south as Skipness he had been able to detect nothing else. The distance from Tarbert to Skipness in a straight line is about 7 miles, though by the road it is 12. The lie of the coast at this part is N. by W. to S. by E. The strike of the rocks is N.E. to S.W.; the dip is "everything by turns and nothing long"—for the most part it seems vertical. If they were vertical throughout, we would have here represented a very great thickness of strata, probably over 20,000 feet.

The map shows that at Skipness they dip to the S.E., and at Ardrishaig to the N.W. It thus appears that these two lochs of East and West Tarbert run along, and have been eroded out of, the crest of an anticlinal axis. Nothing could more effectually illustrate the fact that the surface configuration of the country is due to epigene agencies, or more strikingly show the amount of change which it has undergone.

To the north and west the strata become much more varied in

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character. In walking along the road, which runs pretty close to the shore from Tarbert to Ardrishaig, a distance of 11½ miles, we meet with beds of limestone and sandstone, also volcanic rocks of a distinctly basic character. About 2 miles down the Campbeltown road there is a small quarry to the right opened up for road metal, in which three different kinds of stone occur—(1) A bed of limestone about 18 inches thick, standing vertical; (2) alongside of it, a bed of hornblende schist; and (3) cutting them both at right angles, a dyke of unusually fine-grained basalt. The hornblende schist Mr. Hill regards as an intrusive igneous rock, meaning, not that it was intruded amongst these rocks in its present condition and as they at present stand, and might therefore be fairly considered as a trap dyke (of which there are some in the neighbourhood, differing in no way from the normal crystalline condition of dolerite), but that it was intruded amongst them in the condition of a dolerite, and as a horizontal sheet, and that it has been tilted and crushed along with them. The evidence of this intrusion consists in the great alteration which is effected in the limestone where they come into contact. Similar features have been observed in other localities in the neighbourhood, where the greenstones had altered the sandstones with which they had come into contact into quartzite, and had themselves subsequently passed into hornblende schists. [Specimens were laid on the table illustrating these changes.]

This is a point of some interest, and one which I have not seen noted in any text-book. Schists are usually regarded as metamorphosed sedimentary rocks, which, from being soft and pulpy mud, have by heat and pressure been partially melted and pressed out into schistose splintery form. Every gradation in this process can be traced, from quite unaltered sediments to the most schistose or slaty, and even to a crystalline condition. But it is of interest to note that this process can sometimes be reversed, and that by a re-fusion of a crystalline rock and by pressure it can be made to assume the character of a schist. Mr. Teale, *Quarterly Journal Geol. Soc.*, May, 1885, describes a reversion of this kind which he had traced in a dyke of dolerite near the village of Scourie in Sutherlandshire, and which he illustrates with a drawing of the rock, showing the transition from the granular to the foliated structure, and also with microscopic sections.*

* Mr. Hill mentioned that he had traced a similar reversion in granite rocks, of which he had considerable experience, having been previously stationed in Cornwall.

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Two miles farther on the same road, in a field to the right, there has been opened up another bed of limestone which is estimated to be about 40 feet in thickness, but not being of good quality the working has been abandoned.

Two miles north, on the road to Ardrishaig, in a wood to the left, another bed of limestone occurs, and is at present being worked. About 15 feet of it is exposed, and it is very crystalline in texture. In none of these limestones have any fossils been met with. Farther on, a bed of very fine-grained, highly-indurated sandstone has been opened up for road metal; it is largely charged with iron, and gives to the roads quite a bricky appearance. (Specimens shown.)

As we approach Ardrishaig, we come to what is indicated on the map as a higher horizon of strata, and begin to see the north-western dip of the rocks, and also the intrusive volcanic rocks which are there indicated. The chips of volcanic rocks which I got there are of the usual crystalline character; it is nearer Tarbert—nearer to the centre of the anticlinal axis, where the greatest pressure must have occurred—that they assume the character of hornblende schist.

Geological Age.—These rocks are all assigned to the Lower Silurian period. This was Murchison's famous generalization, with which, probably more than anything else, his name is associated. From the first, however, it did not receive the unanimous consent of geologists to all the extent which Murchison claimed for it. Sedgwick fought most stubbornly the battle for *Cambrian*. Prof. Lapworth and others regard its several horizons as being sufficiently distinct to merit distinct names, and have suggested the terms "Ordovician," "Dimetian," etc., as being more appropriate for the districts or groups which they represent; whilst the recent revolution in our knowledge of Highland stratigraphy seems to throw suspicion on all the knowledge hitherto acquired on this subject, confessedly one of the most difficult in the whole range of the science.*

For wide districts there appears to be no such thing as a "system" or "formation"; the apparent base of a formation in one place is not the base in another, and the boundaries are perpetually open to dispute. Such terms are true only for limited

* See *Nature*, 13th Nov., 1884, vol. xxxi., p. 29. Also Dr. A. Geikie's "Text Book," 2nd edition, 1885, p. 574.

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areas, and are at all times subject to modification by further discovery. All we need say at present is that these strata, by whatever name they may be called, are evidently all older than the Old Red Sandstone.

Glacial Phenomena.—The glaciation of this district has been from the N.E. It is chiefly seen in the rounded form which its innumerable projecting masses assume, all of which show their abrupt faces to the S.W. I ascended the hills on the south side of Tarbert fully 1,000 feet, and everywhere the same features presented themselves. As in Bute and many other places, the smoothing agent evidently travelled *across* the peninsula. Boulder clay occurs only in very small patches. The perched blocks are all of a schistose character.

No. VIII.—Notes on the Geology of Oban. By Dugald Bell, Vice-President.

[Partly read 10th January, 1884.]

In going northward to Oban a geologist's first impression is that he has passed over a great anticlinal axis, on the other side of which he finds repeated over again the same strata as he had previously seen. Thus, crossing the Old Red Sandstone and its conglomerate at Balmaha on Loch Lomond, and at the opening of the Firth of Clyde near Cardross, and leaving the clay-slate which appears at Luss, Rosneath, Inellan, and Bute, he enters upon a tract of mica-slate and other varieties of schistose and quartzose rocks extending along Loch Fyne, the Crinan Canal, and the western coast of Knapdale. Then at Easdale he comes on the clay-slate again, and immediately after, along the Sound of Kerrera onwards to Oban, he sees a well-marked conglomerate, which he is apt to take as, of course, the Old Red conglomerate resting on the clay-slate of the district as before. A further examination, however, will probably show that this conclusion is by no means certain, and that from the way in which patches and detached areas of newer formations occur in the immediate proximity of the old slate rocks all along

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this western coast, the determination of the true age of this conglomerate may be attended with considerable difficulty.

The conglomerate is covered over by great sheets of trap rock which extend eastward to the Pass of Brander, and southward to near Loch Melfort, forming that expanse of lochan-dotted heatherland known as the Lechan Muir. In the neighbourhood of Oban the relative position of the rocks is sometimes very confused—the slate here and there rising into knolls and ridges apparently above the conglomerate, and the trap sometimes, even at lower levels, resting directly on the slate, indicating, evidently, great inequalities in the surface on which both the conglomerate and trap were originally laid down; and also, no doubt, much subsequent faulting and denudation. On the whole, however, the succession manifestly is—slate overlaid by a massive conglomerate, and that again by wide-spreading sheets of igneous rock. The slate is not at present in dispute; but, regarding the age of the conglomerate and the trap, there has been much diversity of opinion.

In this paper we propose to review briefly the various conclusions which geologists have arrived at regarding the age of these Oban rocks. Perhaps such a survey may be useful as a geological study, and may incite some one who has the time and opportunity to collect, if possible, the further evidence which seems still to be required on the subject.

I. Dr. John Macculloch, that industrious pioneer in Scottish geology, who did a wonderful amount of work in his time, and whose observations are being followed with increased respect at the present day, referred to these rocks generally in his description of the island of Kerrera ("Western Isles," vol. ii., p. 110). He began with the "argillaceous schist" as the lowest rock; then noticed a slaty breccia which is found overlying it in some places. Next in order he placed the sandstone and conglomerate, remarking on the great variety of substances imbedded in the conglomerate, and particularly the number of pebbles of the various trap rocks. Lastly, he mentioned the trap "which if not absolutely always uppermost, presents sufficient indications of its posteriority to all the other rocks." He thought there must have been "two distinct formations of trap, one prior to the deposition of the conglomerate, and one posterior; the former being the source of the fragments it contains, and the other now overlying and intersecting the beds." Numerous veins found here and in other parts of

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the coast and islands he regarded as proofs of a third period of volcanic action.

The sandstone series he considered as "analogous to that which in other parts of this country separates the primary from the secondary strata"—that is, to what is commonly called the Old Red, though he admitted that it differs from the sandstone usually found in that position, in its broken and interrupted character, and in the nature of its materials. These, however, he accounted for by its having been formed in the immediate vicinity of trap rocks.

II. When Hugh Miller visited the locality in the course of his "Summer Rambles to the Hebrides," now more than thirty years ago, he made no doubt about this being his "ancient friend, the Old Red conglomerate." Having observed how it lies "unconformably along the edges of the clay-slate, which present under it an appearance exactly similar to that which they exhibit under the rolled stones and shingle of the neighbouring shore," he was moved to even unwonted eloquence by the thought that "in the incalculably remote period in which the conglomerate base of the Old Red Sandstone was formed, the clay-slate of the district had been exactly the same sort of rock that it is now. Quarries might have been opened in this rock, as now, for a roofing slate, had there been quarriers to open them or houses to roof over; it was in every respect as ancient a looking stone then as in the present late age of the world." ("Cruise of the Betsey," p. 6.) Assuming the conglomerate to be Old Red, this fact is doubtless sufficiently striking as proving the far greater antiquity of the slate, and the changes that had passed over it before the conglomerate was laid down. But, of course, this unconformity and these changes do not of themselves prove the conglomerate to be Old Red. Indeed, the greater the unconformity between the slate and the conglomerate, and the more striking the changes which the former can be shown to have undergone before the latter was laid down upon it, the stronger, we may say, requires to be the proof that the conglomerate really belongs to the Old Red, and not to a later formation. From the great size of the boulders imbedded in the conglomerate, particularly in the Dog-Stone of Dunolly, Miller argued ingeniously in favour of its high antiquity—that when it was formed this shore was exposed to the full sweep of the Atlantic waves, before Mull and Kerrera acted as breakwaters. But there are so many ways in which conglomerate may be formed—by torrents

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and ice, as well as by the sea—and so many "accidents," if we may so speak, by which large blocks may get into conglomerate, that we hesitate to accept this as conclusive.

III. The late Professor Nicol, of Aberdeen, whose views on the geology of the Highlands generally have lately been confirmed in a remarkable degree, placed these rocks in the Permian or Trias, or perhaps even a later formation. In his "Guide to the Geology of Scotland" (1844), referring to MacCulloch's view of there being two or three distinct formations of trap, he wrote—"It may, however, be observed that the age of this sandstone is altogether uncertain, and that the trap may have occupied a long period in its formation." But in the "Explanatory Note" to his "Geological Map of Scotland" (1858), he ventured on a more definite opinion. "In this group," he said, speaking of the Permian and Trias, "I am disposed to place the conglomerates and red sandstones near Oban, almost entirely made up of the detritus of trap-rocks. Resting unconformably on the clay-slates, and covered over by trap, they furnish no very certain marks of the period when they were formed; but they are evidently more closely connected with the Lias of Mull and the Trias of the North of Ireland than with the Old Red Sandstone in other parts of Scotland."

IV. Dr. A. Geikie, after first assigning it to the Oolite and then to the upper Old Red (see Geological Maps of Scotland, 1861 and 1876 *), now inclines to the lower Old Red as the true age of this Lorne conglomerate. In token of this he has named from it one of his "lakes," those great inland waters—Lake *Orcadie*, Lake *Caledonia*, Lake *Lorne*, and Lake *Cheviot*—in which he believes the Old Red in Scotland was deposited. But Dr. Geikie's exposition of the subject is still incomplete. The paper to the Royal Society of Edinburgh, 1879, in which he marked out these four separate areas of deposition, dealt in detail with only the first, namely, Lake Orcadie, and the reasons for assigning this Lorne conglomerate to the lower Old Red have not yet been given

* Professor Judd, in his paper in the *Quar. Jour. Geol. Soc.*, vol. xxx., to which we shall again refer, states that "in the map of Scotland published in 1861 by Sir R. Murchison and Professor Geikie the 'traps' of Lorn are indicated as being of Old Red Sandstone age." This is a mistake. In the map referred to these traps are both coloured and lettered as of *Oolitic* age. In Professor Geikie's map of 1876, however, they are coloured and lettered as belonging to the *upper* Old Red. More recently Professor Geikie adopted the view that they are lower Old Red.

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to the world. In his recently published "Text-Book," Dr. Geikie names Lake Lorne as one of the minor areas of the lower Old Red Sandstone, and says it "occupied a basin on the flanks of the south-west Highlands which is now partly marked by the terraced volcanic hills of Lorne." He alludes at some length to the organic remains found in the Old Red of the central and northern basins; but nothing of the kind is adduced from the other two, *Cheviot* and *Lorne*. He merely remarks that in them "volcanic action continued long vigorous, and produced thick piles of lava, like those of Lake Caledonia." (Second edition, pp. 712-714.)

V. Professor Judd, whose researches among both the igneous and the sedimentary rocks of the Western Highlands have added so much to our knowledge of the geology of these regions, in the second of his valuable papers on "The Secondary Rocks of Scotland," discusses at some length the "age of the volcanic series of Lorne."* In the absence of palæontological evidence, he says "the question must be admitted to be still to a certain extent an open one." But he enumerates some "facts to guide us" in forming a judgment concerning it, and these, with all respect, we shall now consider. They are—

(1) "The very marked unconformity between these rocks and the strata of lower Silurian age on which they lie." This, of course, proves that the conglomerate is more recent than the slate, but, we need hardly remark, does not of itself determine *how much* more recent it is.

(2) "The fact that the Mesozoic strata appear to rest upon them [*i.e.*, upon these Oban rocks], and in some instances at least quite unconformably." This would be important if clearly made out, but it is stated so doubtfully that it seems impossible to rest much upon it.

"The only point," says the Professor in a previous page, "at which the series of rocks so well displayed in Lorne is seen in juxtaposition with the Mesozoic sedimentary rocks and the Tertiary lavas is in the south-eastern part of Mull. Here, unfortunately, among the wonderfully disturbed and greatly metamorphosed rocks I have sought in vain for any simple section illustrating the relations of these three series of deposits. Nevertheless, after carefully tracing the positions of such masses as can be reached and studied, there appears to be no room for doubt that the various members

* *Quar. Jour. Geol. Soc.*, vol. xxx. (1874), p. 287.

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of the Mesozoic series rest indifferently upon the denuded lavas of Lorne and the older rocks." (P. 282.)

With the greatest deference to Professor Judd's own opinion, we think it evident from the guarded manner in which he expresses it, that he does not regard the evidence under this head as quite clear or conclusive.

(3) The third "fact" the Professor adduces is "the resemblance which the lava streams, of which they [the Lorne rocks] are so largely composed, present in their petrological characters to others on the south of the Grampians, which sometimes alternate with strata containing fishes of Old Red Sandstone species." This argument from resemblance was probably of more weight to geologists some twelve or fourteen years ago than it is now. At that time it was generally supposed that the age of volcanic rocks might be determined, or inferred with some degree of certainty, from their general appearance and characteristics, whether they were acid or basic, more or less crystalline, etc. But since then the conclusions to which those who have specially investigated the subject have been led point very much in the opposite direction. It is now held by such authorities that the resemblance between Palæozoic traps and those of Tertiary age "is often so great that they cannot be distinguished from each other"; and that "difference in geological age is not accompanied by difference in composition and structure." * Or, as Professor Judd himself has more recently expressed it, the differences between igneous rocks "are not to be accounted for by a difference of geological age, but are a consequence of the diverse conditions under which the rocks had consolidated." † Further, in some parts Tertiary volcanic rocks have undergone such changes that they "are in no way distinguishable from the amygdaloidal melaphyres and similar rocks which have usually been regarded as characteristic of the older geological periods." ‡ If this be so, it would seem that, without the proof afforded by their relations to sedimentary rocks, whose age on palæontological evidence is undoubted, to determine the age of

* See a very interesting paper by S. Allport on "The Microscopic Structure and Composition of British Carboniferous Dolerites," in the same vol. of the *Quar. Jour.* as that in which Professor Judd's paper appears, viz., vol. xxx., p. 529.

† *Quar. Jour. Geol. Soc.*, vol. xlii. (1886), p. 50.

‡ *Ib.*, p. 84.

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igneous rocks by general appearances, characteristics, or "resemblances," is an entirely hopeless task.*

On the whole it may be said that the only direct evidence yet adduced as to the age of these Oban rocks is that afforded by the somewhat doubtful appearances presented on the south-eastern coast of Mull, as to which we have already noted Professor Judd speaks with much hesitation and reserve. He concludes in favour of regarding the volcanic and associated rocks of Lorne as "belonging to some part of the Newer Palæozoic periods," adding that "to hazard any closer approximation to their age would probably be unsafe."

VI. In Professor Blackie's delightful book, entitled "Altavona," there is a graphic sketch of the geology of the Oban district, in the shape of a lecture given after a pic-nic at Gylen Castle to the highly-favoured company there assembled. The lecturer is represented to be "Hilarius," one of H.M. Inspectors of Schools, and "most ubiquitous of mortals"; a description from which some readers will profess they can easily identify the lecturer. But we are always disposed in such cases to respect an author's *incognito*, and will only say he is evidently one who loves the Highlands and knows them well. "Hilarius" adopts and sets forth Dr. A. Geikie's view as to the Old Red age of these conglomerates and associated lavas, but with some modifications of his own. The conglomerate, he states, was laid down in the depths of that "ancient Old Red loch," Lake Lorne. "Moreover, in the greater part of Kerrera here, and between the Firth of Lorne and Loch Awe there stretch broad deposits of volcanic rock which various indications prove to have been thrown out during the Old Red era." Then, certain dykes of basalt and porphyry which intersect the slates but not the conglomerate "are probably extensions of the great volcanic beds of the Lechan Muir," and so the conclusion is reached that "these beds also existed before the conglomerate was laid down, resting on them, as it also does in some sections." ("Altavona," pp. 131-133.)

* "Many difficulties remain yet to be explained before our knowledge of volcanic action can be regarded as more than rudimentary. Why should two neighbouring vents sometimes eject, the one acid, the other basic lavas? Why should even the same vent occasionally exhibit an alternation of acid and basic eruptions? To these and other questions in the mechanism of volcanoes no satisfactory answers have yet been given." Dr. A. Geikie: "Text Book," 2nd ed., p. 250.

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Now, we should suppose, few men can state a geological problem more clearly than "Hilarius," but here we confess ourselves unable to follow him. Granting that there are older dykes intersecting the slates which do not penetrate the conglomerate (and which are to be carefully distinguished from the more recent dykes which intersect slates, conglomerate, and in some instances volcanic beds, all alike)—it seems impossible that these older dykes can be extensions of the volcanic beds of the Lechan Muir. Why? Because the conglomerate comes in between them. Nay, says "Hilarius," it rests on the volcanic beds, at least "in some sections." Well, whatever intermixtures of volcanic rocks with the conglomerate may in some parts be observed, we had thought it beyond dispute that the broad tract of volcanic rocks forming the Lechan Muir *overlies* the conglomerate. We might refer again to the observations of the geologists already named, who all agree in this. But let any one look at the sections exposed along the shore and in the neighbourhood of Oban for himself. And if there still be any doubt on the point, then a distinct reference to the sections which are said to show the conglomerate resting on these volcanic beds would be valuable, and save much time.*

But, allowing for the moment that the fact be as now stated, what light does it throw on the alleged Old Red age of the conglomerate? "No light, but rather darkness visible." For, if the volcanic beds of Lechan Muir be "proved by various indications" to be of Old Red age, and if the conglomerate rests upon these beds, then (without troubling ourselves about the dykes, which after all only result in a probability) we are led straight to the conclusion that the conglomerate is *newer* than the Old Red. Or, to be quite exact, it is at least newer than some portions of the Old Red, and for aught that appears, may be newer, much newer, than any portion of it. Certainly as regards "proof" of either the volcanic beds or the conglomerate being of Old Red

* Professor Judd gives several sections showing the trap resting indifferently on the slate or on the conglomerate, but not one showing the conglomerate resting on the trap. And he says expressly—"The sandstones and conglomerates appear to be wholly confined to the *lower* part of the volcanic series of Lorne. In its upper part, that series consists of stream after stream of lava piled one upon the other in almost endless succession; and, so far as I have observed, these include between them no stratified deposits."—*Quar. Jour. Geol. Soc.*, vol. xxx., p. 285.

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age, this interesting lecture at Gylen Castle leaves us very much where it found us—"no forrarder." *

It thus appears that the age of these Oban rocks is still undecided—still, as Professor Judd has said, "an open question"—no evidence on the subject that can be regarded as at all conclusive having yet been adduced.

We may now add a few miscellaneous notes on this much-debated conglomerate and its surroundings. First, with regard to its *composition*. That it is mainly formed of the detritus of trap rocks is a point on which all observers are agreed. There are scattered throughout the mass, in some parts more plentifully than in others, pebbles of yellow and white quartz, together with fragments of various kinds of schistose rocks, and also, according to some observers, of granite. But its distinguishing characteristic is the great number and variety of trap rocks—in masses large and small, some, indeed, of very great size—which it contains. Macculloch regarded it as in this respect different from any other conglomerate which he had seen in Scotland, and instances among the contents "basalt, greenstone, amygdaloids, cavernous trap, and clinkstone, or compact felspar; together with those porphyritic or other modifications that are found associated with the rocks of this extensive family." † There have been changes in the nomenclature since his day, but these do not affect his observation of the number of different kinds of these rocks imbedded in this conglomerate. Nicol describes it in similar terms.‡ Hugh Miller—though, as we have seen, prejudging it to be Old Red—also took notice of the great variety of these imbedded pebbles of trap, and particularly of the fact that many of them "seem identical in their composition with rocks of the trap family, which in other

* It is only right to add that the esteemed lecturer is understood to have since modified in some respects the views on these rocks set forth in the work referred to. We believe he may now be taken as concurring in the opinion expressed in another paper in the present volume (p. 73), to the effect that while the conglomerate belongs to "the ancient Lake Lorne of Old Red times," the age of the trap region behind Oban "still requires final determination." But if the conglomerate belongs to the same series as the trap, and especially if it belongs to the upper part of that series, *its* age must require "final determination" also.

† "Western Isles," vol. ii., p. 117.

‡ "Geol. of Scotland," p. 158.

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parts of the country we find referred to much later eras. There occur," he added, "in this deposit rolled pebbles of a basalt which in the neighbourhood of Edinburgh would be deemed considerably more modern than the times of the Mountain Limestone, and in the Isle of Skye considerably more modern than the times of the Oolite." *

Not only the larger contents of the conglomerate, but also its finer portions—the base or matrix in which these masses are imbedded, and the bands or lenticular patches of stratified material interspersed through it—seem to be chiefly composed of the waste and washings of the igneous rocks. These interbedded layers vary in colour and texture from fine reddish bands to a coarse-grained grey or brownish sandstone; but these seem to be merely local varieties, without any definite order of succession; and both alike appear to derive their material chiefly from the waste of volcanic rocks.

As to the condition of the various imbedded masses, they are generally well-rounded, indicating that they must have been subjected for a considerable period to the action of running water, or more probably of waves. No marks of glaciation have yet been observed upon any of them; but we must not hasten to conclude from such negative evidence that some former ice age may not have had to do with the formation of this conglomerate.

This preponderance of trappean material, and the great size of many of the masses imbedded in the deposit, render it extremely probable that the whole was brought from no great distance,—that the tract of volcanic rocks from which the component parts were mainly derived was situated in the immediate neighbourhood. Looking to the admixture of coarser and finer materials, the likelihood is that they were brought down by torrents to the shore either of the sea or some lake, where they were afterwards subjected to the attrition of the waves. †

* "Cruise of the Betsey," p. 9.

† We are inclined to say the *sea* shore, not forgetting the "lake theory," but because we cannot help thinking it exceedingly improbable that such accumulations of well-rounded material should be found on the shores, not to say "in the depths," of any inland lake. We have often been struck with the scanty amount of rounded shingle on the shores of all the inland lakes we know. Nor do we think that torrents or floods, caused by the sudden melting of snow, etc., could of themselves produce such heaps of rounded stones of all sizes as are here brought together. To give rise to

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Professor Judd is of opinion that the series was "accumulated along the flanks of a range of lofty volcanoes, the heaping up of conglomerates by mountain torrents, and the outpouring of lava-streams, under which these were buried and preserved, going on side by side." This agrees also with the "local and irregular character" of the conglomerate, which seems to have been accumulated in certain deltas, as fan-shaped masses of alluvium are formed by mountain streams at the present day.*

On the assumption that the conglomerate is of Old Red age, the first and most obvious conclusion is that the abundant and varied fragments of igneous rock which it contains were derived from the older (Silurian or Cambrian) formations. In the words of Macculloch, "it follows that the fragments of trap existing in this rock have, like the other substances, been derived from previous masses of that rock of a date prior to the deposition of the secondary strata, and equally, therefore, to be ranked with the other primary strata, by the fragments of which it is accompanied." Macculloch, however, saw and expressed the difficulty this conclusion involves, for he added that, as may be deduced from many parts of his work, "the trap rocks are usually associated with the secondary strata, and are, in by far the predominant examples,

anything like the contents of this conglomerate, the ceaseless action of the sea, and the sweep of its powerful waves, seem indispensable.

[Since the above was in type some interesting observations on the formation of grits and sandstones have appeared in Prof. Bonney's Opening Address to the Geological Section of the British Association for the present year. This eminent geologist lays it down as a principle that "pebbles indicate the action either of waves of the sea, or of strong currents, marine or fluviatile." In a note he adds—"The waves of lakes also have some rounding effect, but this—except in the case of very large lakes, such as Lake Superior—is not important; and such cases are, of course, not of common occurrence." At the same time he thinks it "probable that a thick and very widely-extended pebble bed is not the result of wave action," seeing that "the zone in the sea over which the manufacture of pebbles can be carried on is generally a very narrow one." Beds of gravel and coarse sand, of considerable vertical thickness and great extension, he considers most likely indicate river action (*Nature*, 9th Sept., 1886). How far this applies to such comparatively local deposits as the Oban conglomerate, with the large-sized rounded masses imbedded in it, may be a question.]

* See *Quar. Jour. Geol. Soc.*, vol. xxx., p. 286.

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superior to them; while the instances in which they occur in union with, or immediate superposition to, the primary, are comparatively rare." * Notwithstanding the advance of geological knowledge since his day, particularly as regards the older Palæozoic rocks, then called "primary," we may still take this statement as correct, so far as our own country is concerned. Although there are abundant evidences of volcanic action during Cambrian and lower Silurian periods, in the North of England, in Wales, and the South of Ireland, these are "comparatively rare, if not, indeed, entirely awanting in the corresponding formations in Scotland." † Of course, we do not here refer to intrusive dykes, which may be, and can generally be shown to be, of much later age.

This difficulty is perhaps obviated in some degree by supposing that the fragments of igneous rock in the conglomerate, the conglomerate itself, and the overlying volcanic beds, all belong to one period, namely, the Old Red, and indicate different phases of a prolonged volcanic activity during that epoch. According to this theory, the earlier lava-flows were succeeded by a time of powerful denudation, during which they were broken up and waterworn, and heaped together into this conglomerate; and then followed a time of renewed and greater volcanic activity—greater at least in relation to the denuding agencies—when the overlying beds of igneous rock, still so massive and continuous, were laid down. Whether the great variety of trap rocks imbedded in the conglomerate, to which we have referred, and which seems to be sufficiently well attested, does not still present a difficulty in regarding the deposit as of Old Red age, we must leave to others more competent to determine. We merely remark that, according to this view, there must have been a range of "lofty volcanoes" in the neighbourhood of Lorne during the Old Red Sandstone epoch; and the question arises, Apart from this conglomerate itself, which is in dispute, are there any collateral or independent proofs of the existence of such volcanoes in this neighbourhood at that time?

The interbedded volcanic rocks of the Old Red in other parts of the country occur "several thousand feet above the base of the

* "Western Isles," vol. ii., p. 120.

† "No very distinct traces of contemporaneous volcanic activity have yet been detected among rocks of that [Silurian] age in Scotland."—Jukes and Geikie's "Manual" (1872), p. 561.

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system," and are "succeeded by thousands of feet of sandstones, shales, and conglomerates, without any intercalation of lava or tuff." * Here it is remarkable that, both beneath and above the volcanic rocks, there is, so far as yet observed, a total absence of any such strata.

Again, in a survey of the volcanic rocks of our country, we find "there are indications that the eruptions were apt to occur along lines of broad valley." The long depression between the Highlands and the Southern uplands, for example, was "the site of active volcanoes during the Old Red Sandstone and Carboniferous periods"; while "the Tertiary basalts of the north-west lie in a long hollow (at least as old as the Lias) scooped out of the metamorphosed Silurian and Laurentian rocks." † This generalization may be only approximately correct; but whatever weight may be attached to it, it is evident that volcanic rocks in the neighbourhood of Oban are much more in the line of Tertiary volcanic activity than in that of older periods as here laid down.

Though evidently doubtful regarding the age of the Oban conglomerate, and only concluding that it is "analogous" to that which, in other parts of the country, "separates the primary from the secondary rocks," Macculloch certainly regarded the associated and overlying trap rocks as closely related to the adjacent volcanic rocks of Mull, Morven, Ardnamurchan, etc. He speaks of "the general trap district of Mull and Lorne," ‡ holding that "the various disjoined masses have actually been once continuous;" § and, as we have already seen, he had no doubt that these traps are posterior to Secondary strata.

In this connection we may also allude to one of Prof. Judd's later papers, in which he regards that large tract of volcanic rocks extending from Iceland, through the Faroe Isles, St. Kilda, Skye, Eigg, Mull, and other islands, with parts of the adjoining mainland, to the north of Ireland, and including also, he is disposed to think, the island of Arran, as forming "one great petrographical province," the igneous masses of which, "from the most acid to the most basic, and including representatives of every variety of structure, from the most highly crystalline to perfectly vitreous types, are all of post-Cretaceous age." ||

* A. Geikie, "Text Book," 2nd edition, p. 713.
† A. Geikie, *Address to Section C, Brit. Assoc.*, 1867.
‡ *Loc. cit.*, p. 121. § *Ib.*, p. 78.
|| *Quar. Jour. Geol. Soc.*, vol. xlii., p. 58.

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We know also, in great part from Professor Judd's own researches, that not only was this tract of volcanic activity an extensive one, but that it was so during a long protracted period. We know that there were intervals of long duration in the action of the volcanic forces, during which beds of soil were formed, and plants and trees took root and grew, and streams hollowed out channels for themselves on the surface of the underlying beds of igneous rocks; all of which were covered over by subsequent lava-flows; and, in short, that the whole of these "piles of ejected materials" were subjected to enormous denudation long before they ceased to receive further accessions from the action of the eruptive forces.

Surely, the proof ought to be strong which requires us to assign this adjacent patch of volcanic rocks, and of conglomerate largely composed of the debris of such rocks, to an entirely different era.

We have alluded to several writers as having stated that the Oban conglomerate contains fragments of granite.* If this be so, it adds some weight to the considerations in favour of the conglomerate being of more recent date than has been so frequently assigned to it. The granite protrusions of our country are generally admitted to be subsequent, many of them evidently long subsequent, to the formation of the Old Red conglomerate.† But as we have not been able by our own observation to confirm this statement, we do no more than mention it, entering at the same time a *caveat* against the *absence* of granite (should this be established) being taken as conclusive on the other side. It may be true that, so far as known, no Old Red conglomerate contains granite; but it does not follow that all other or later conglomerates must contain it.

Another circumstance that may be noted is, not only the local and detached character of this conglomerate, but its comparatively undisturbed position—the entire unconformity and disconnection, so to speak, between it and the underlying slate rocks. It differs in this respect from the undoubted Old Red conglomerates in

* *E.g.*, Macculloch, Nicol, and Miller.

† The absence of pebbles of granitic rocks from the conglomerates of the Old Red Sandstone has often been remarked upon, as, for example, with regard to the conglomerate in Arran.

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other parts of the country. These, although certainly unconformable to the underlying schists, are yet in every case much disturbed, and tilted up for considerable distances at a high angle, showing unequivocally that great movements of the earth's crust have taken place since their deposition, by which, along with the rocks on either side of them, they have been powerfully affected.*

Taking all these points—more or less important as they may be regarded—into consideration, may we not conclude with Prof. Nicol, that these conglomerates and associated volcanic rocks in the neighbourhood of Oban are more closely connected with the volcanic and sedimentary rocks of Mull and the North of Ireland, than with those of older date in other parts of the kingdom?

At least, I think we are entitled to say that the question as to the age of these rocks requires further investigation; and it is for this reason that I have ventured to bring the subject (at perhaps too great length) before the members of this Society.

The addition of a few local notes, however brief, may still make this paper less incomplete.

On the north side of the bay, towards Dunolly, the slate crops up here and there along the shore, in some parts almost vertical, in others dipping to the north-west. Near the Dunolly gate we find the conglomerate—including numerous bands of sandstone—overlying the slate unconformably, and dipping at a low angle to the south-east. Here it contains many quartz pebbles, but as we follow it towards Dunolly, in the neighbourhood of the Dogstone and farther on, it seems to become more exclusively trappean in character. It is well seen in the wood beside the approach to the Castle, and extends backward about half-way up the hill, where it is succeeded by the volcanic rocks.

Returning to the village, we observe in the street at the head of the quay the strata of slate come to the surface with a northerly dip as before. In the cliff behind the village we can still see a section similar

* Macculloch, with his usual accuracy, notes this irregular local position of the conglomerate as a "circumstance in which this rock differs from that which usually separates the primary and secondary strata." (Vol. ii., p. 117.)

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to that described by Hugh Miller—the thick mass of conglomerate resting on the upturned edges of the slate, with at one part a thin bed of breccia between. If we make our way to the top of the hill, beside the unfinished buildings of the Hydropathic Establishment, we find it capped with volcanic rock.

Farther south, as we leave the village by the old Connal road, the slate re-appears in a high cliff overgrown with ivy; and behind it, to the east, the conglomerate again, with numerous blocks strewn at the foot. Then, a little farther on, we come once more to the trap, in which a large quarry is wrought.

We are now in what may be called the "old bay" of Oban—the bay that was occupied by the sea before the "last elevation" of the land, and which extends a considerable distance inland from the line of the present bay and harbour. The railway sweeps along the southern side of it, gradually rising to the undulating heights of the Lechan Muir.

There has evidently been much denudation here, and it is not easy in some places to make out the true relations of the rocks.

At one part the conglomerate rises in a large knoll or hillock, which in all likelihood formed an island near the head of the old bay. In this "island," as in some of the sections seen along the shore, the lower portions are of finer material, forming sandstone, and the upper portions more conglomeratic in character.

Coming down to the railway, the first deep cutting after leaving the station is through the slate, in which a large quarry is wrought immediately adjoining. The strata here are much contorted, and are intersected with a number of quartz veins. A few hundred yards farther on, the line cuts through a knoll of trap-rock resting directly on the slate. The section shows about twenty feet of rudely columnar trap, with the slate beneath, a good deal altered by contact with the igneous rock. Near the cutting, a large dyke is seen to intersect the slate in a direction from west to east. North of the quarry, a detached ridge of conglomerate rests on the slate. It is chiefly trappean in its composition—not much, if any, quartz or schist being discernible.

On the south side of the bay we see at several points the strata of slate on the shore; the old sea-cliff of conglomerate, assuming many picturesque and sometimes fantastic forms, rises high beside the road, all the way down to the Kerrera ferry-house; and over all, as we can easily prove by taking the hill-road on our return, extends the "trap region" of Lorne. But in many parts the relations of these rocks require further elucidation.

In his section along the southern end of the island of Kerrera (*Quar. Jour.*, vol. xxx., p. 284), Prof. Judd shows "lavas of Lorne" resting on slate to the east of the old castle, and resting on sandstone and conglomerate to the left of it. This conglomerate is said to contain "many

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pebbles and blocks of the lavas of Lorne," and yet is shown to be covered over by these lavas. Of course, it could not be formed out of the very lavas which overlie it; the explanation adopted being, as stated, that at one period the conditions were such that the lavas were broken up and more or less water-worn, while at a later period they retained their form as continuous sheets of igneous rock.

The conglomerate on which Gylen Castle stands, the Professor notes, is "mainly composed of pebbles and blocks of lower Silurian rocks." He thus apparently makes out *two* conglomerates, or at least two adjacent portions of the same conglomerate, differing considerably from each other. He evidently holds, however, that it is the same conglomerate—some portions being more exclusively trappean, and others containing a larger admixture of schists and quartzes, these varieties being due to local causes, and passing into each other without any discoverable order. Our own impression, given with all deference, from the examination of a good many sections, is that on the whole the lower beds of the conglomerate are chiefly made up of fragments of volcanic rocks, and its higher portions present a greater variety and abundance of other materials.

As showing the confused appearance which in some places these rocks present, and the uncertainty that has existed regarding them, I have annexed, on the opposite page, a copy of Macculloch's ideal section of the island of Kerrera (Fig. i.) and also one of Prof. Judd's section of the same island (Fig. iii.); while in the second diagram (Fig. ii.) I have attempted to fill up Macculloch's outline, so as to make it more intelligible, and show that, notwithstanding the confusion which at first sight it presents, it may yet be taken as corresponding with the sections given by later geologists. (The sandstone in the foreground, though apparently lower in position, of course leans on the schist, and is really superior to it.)

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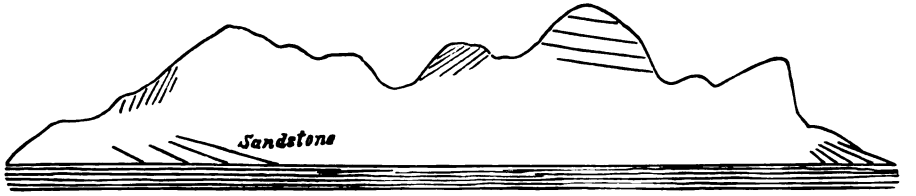
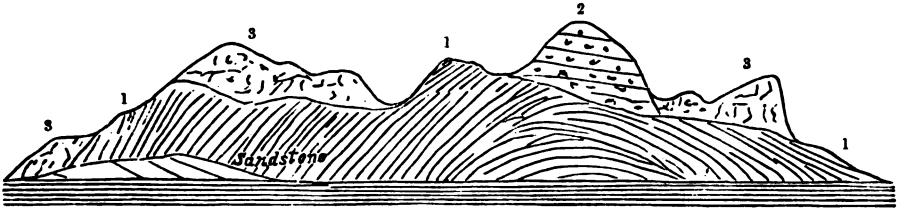
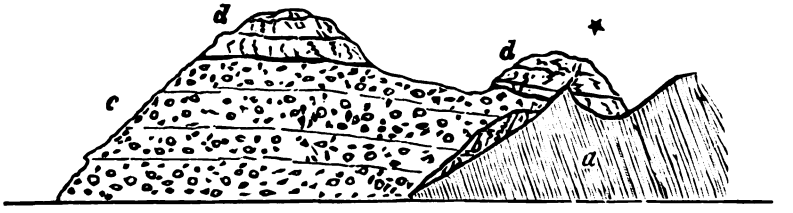


FIG. I.—IDEAL SECTION OF KERRERA (Macculloch).



1. Schist. 2. Conglomerate. 3. Trap.

FIG. II.—MACCULLOCH'S OUTLINE, AS SEEN IN FIG. I.; BUT FILLED UP SO AS TO SHOW THAT IT REALLY CORRESPONDS WITH SECTIONS GIVEN BY LATER OBSERVERS.



a Lower Silurian slates. *b* Breccia composed of angular fragments of *a*. *c* Conglomerates and sandstones. *d* Porphyrite lava-streams. * Slates baked and altered by the enveloping lava.

FIG. III.—SECTION THROUGH THE HIGHEST POINT OF THE ISLAND OF KERRERA, ILLUSTRATING THE RELATIONS BETWEEN THE SLATE ROCKS AND THE OVERLYING VOLCANIC SERIES OF LORNE (Judd).

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No. IX.—Note on the Cathkin "Osmund Stone," a Volcanic Tuff. By John Young, F.G.S., *V.P.*, and D. Corse Glen, F.G.S.

Read 16th October, 1884.

In a paper* on the igneous rocks found in the quarries at Cathkin, we referred to the "Osmund stone," described by the Rev. David Ure.† Since his time further operations in the upper quarry have caused the quarrymen to excavate certain portions of the "Osmund stone" which underlies the thick bed of dolerite used for macadamizing purposes. These portions of rock have been laid on one side at the western entrance to the quarry, and on a recent excursion we were able to obtain specimens of its principal varieties, and also to study what we believe to be some of the conditions under which it was erupted. These present many points of interest, and we exhibit five of the principal varieties of the rock, as well as sections for microscopic examination, so as to illustrate the mineral composition of the tuffs. The prevailing colour of the rock is a reddish brown, interstratified with layers of ash of a light greenish grey colour. It is only moderately hard, and under the influence of the weather some of the beds rapidly crumble down into a rough granular clay. In our former paper we stated that this rock was sometimes used industrially, owing to its property of resisting heat, for the paving of oven soles, but it seems now to be less used than formerly for this purpose.

The Cathkin tuffs are evidently portions of extensive beds alternating with the igneous flows of felstone and dolerite which build up these hills, but as there are few natural escarpments where those rocks can be studied it is impossible to say how far any one of the tuff beds extend in the district, or in what directions they thicken or thin away from the points of eruption, which must be located somewhere in the Cathkin hills.

No. 1 is the variety in which the ejected fragments attain their largest size. These vary from one half inch or more in diameter to less than one quarter inch. They are generally angular in shape, and are composed of felstones, red, brown, and purple in tint, which gives the rock a dark colour. The cement-

* *Transactions*, vol. vii., p. 169, 1882.

† *History of Rutherglen and East Kilbride*, 1793.

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ing material of the fragments in this variety is partly a volcanic dust, some of the larger interspaces being filled with a later infiltration of white calcite. Olivine crystals are seen in some of the fragments of felstone, but are not so abundant as in some of the other varieties. The deep ferruginous colour seems to be due to a staining of peroxide of iron, probably derived from the decomposition of some of the original iron elements of the rock.

No. 2 is a grey variety of the tuff, banded at intervals with a layer of a reddish brown ash. The fragments entering its composition seldom exceed one-eighth inch in diameter, and in sections under the microscope these are seen to be cemented by a bluish white chalcedony, which, in an agatized form, fills up all the cavities between the rock-fragments. This variety when ground in thin opaque sections, so as to be viewed on both sides under the microscope by reflected light, forms a beautiful object. If a section is ground so as to show the red and grey layers on the alternate sides, we then find an assemblage of various coloured rock fragments, consisting chiefly of felstones. These are of all tints and texture, varying from bright brick-red to reddish brown and purple, and also into greys and whites. Along with these are numerous crystals of olivine, some of which, by subsequent alteration, have given a beautiful greenish tinge to portions of the chalcedony and felspar crystals. The rock, in fact, has by this alteration of the olivine become so far serpentinized, as is seen to be the case with many other igneous rocks in which olivine exists. These olivine crystals in the tuff are easily known by their green colour, but under reflected light there are others which shine with a golden bronze metallic tint. The felstone fragments are sometimes compact, sometimes minutely crystalline, and sometimes minutely vesicular in texture, many of them containing small crystals of iron in an oxidized condition. Altogether this variety forms one of the most interesting and beautiful forms of a volcanic rock which we appear to possess in the West of Scotland. It is one that the eye never tires of looking at, as the sections will bear any amount of enlargement under the microscope and yet never look coarse. The setting of the various coloured felstones and olivines in the bluish white chalcedony looks like a piece of brilliant, miniature, mosaic work under the illumination of the microscope, but it is a piece of work that never could be successfully imitated by the most skilful of human hands.

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This volcanic tuff in some of its layers reveals the interesting fact that while being erupted, and ere it fell to the earth, its fragments had so far been assorted by the winds that those which fell over certain areas, and now form certain layers, are of nearly a uniform size of grain. Microscopic sections also reveal the fact that in many of these layers the finer volcanic dust which naturally would have fallen along with the fragments under a still condition of the atmosphere, has been wafted by the winds into other and more distant areas, hence many of these tuffs have been cleaned by a sort of winnowing process, and the interspaces which would otherwise have been filled with fine volcanic dust now contain a later infiltration of chalcedony or calcite. We also think that there is evidence to show that these ashes fell lightly over the earth, and that since they fell they have never been moved by either wind or water from the tracts where they now lie. Had they been moved by either agency evidence would have been seen in the filling up of the interspaces between the fragments by either dust or mud, but such is not the case, for the beds seem to have existed in their open, porous condition until the period when they were permeated by the waters holding the silica and calcite in solution. We may here mention that in the Cathkin quarry silica in the form of a bluish white chalcedony is often found in thin veins or crusts in fissures of the felstones, and also filling up cavities in the vesicular varieties. It has probably been introduced into these rocks at a later period by heated waters holding silica in solution.

No. 3 forms a thin compact band of tuff, which seems originally to have been of a reddish brown colour, and is composed of crystalline and vesicular olivine felstones. It is now, however, curiously mottled, and, in sections examined under the microscope, this is seen to be due to a subsequent discharging of the red colour around the edges, and even to the centres of many of the fragments, which have thereby been bleached under the process into whites and various shades of grey. The agency which has produced this curious appearance has probably been water holding some substance in solution which has acted chemically upon the iron oxides in the rock, but which has not, however, affected in any way the colour of the olivine crystals. This variety of tuff, from its more compact structure than that of No. 2, holds less chalcedony amongst the fragments, and is therefore somewhat

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inferior in beauty as an object for the microscope, although the reds of its felstone fragments are more brilliant.

No. 4 is a fine-grained variety of the tuff, in which the fragments are small, and of a dark, purple brown colour, but when seen under the microscope with a good light they become a more brilliant red, and are seen to contain a few olivine crystals scattered about in the matrix. The rock fragments in this variety, although small, appear to have been well cleaned by the wind before they fell from any finer volcanic dust. This is well seen in a section of the rock which we exhibit, and in which the interspaces between the fragments is now filled with a bluish white chalcedony that contrasts strongly with the dark colour of the fragments, and at the same time clearly shows that the tuff previous to its percolation by the chalcedony must have existed in an open porous condition.

No. 5 is from a compact layer in the tuff, in which the grains are small, and the cementing material is a fine volcanic dust that fills up nearly the whole of the interstices, and consequently sections show very little of the white chalcedony so abundantly present in some of the other porous varieties. Hence this is not such a beautiful stone as the others for sectioning purposes. The chief interest in this variety consists in the way in which the red and grey layers of ashes alternate with one another, giving to the rock a fine banded appearance. We think that there can be little doubt but that they represent distinct showers of ash, and probably from the way in which the red and grey layers of ashes alternate in these Cathkin tuffs they may have been erupted from various necks or vents which were not all in activity at one time, and this may account for the varying colours of the rock fragments and their sharp alternations with one another.

Other varieties besides these could easily be collected, but the five exhibited we consider to be the most typically distinct, and to show best the characters under which we believe them to have been formed. Prof. A. Geikie, in his memoir "On the Carboniferous Volcanic Rocks of the Basin of the Firth of Forth,"* when speaking of the fragmental rocks or tuffs, says (page 513)—"The fragmental rocks do not yield such satisfactory results as the crystalline masses to investigation with the microscope." This, he explains, is owing to the volcanic debris commingling with ordi-

* *Trans. Royal Soc. Edin.*, vol. xxix., 1880.

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nary mechanical sediment, such as sand or silt, and he shows that in the district under review "we are constantly presented with varying mixtures of fine volcanic debris and ordinary mechanical sediment;" and "where the tuffs occur as beds or laminæ, interstratified with sedimentary rocks, the paste necessarily becomes mixed with the sand, mud, or limestone which may have been gathering on the floor over which the volcanic eruptions took place." The almost entire absence of sand, mud, or other mechanical sediments in the Cathkin tuffs indicate, we think, different conditions of deposition from those described by Professor Geikie, and, as formerly stated, we are inclined to believe that these beds were deposited on land above water, the cementing material of silica and calcite being afterwards carried into the porous tuffs by the slow permeation of waters holding these minerals in solution.

No. X.—Notice of the late Dr. Thomas Davidson, F.R.S., F.G.S., *Honorary Member*. By John Young, F.G.S. *V.P.*

[Read 10th December, 1885.]

I am very sorry to have to ask you this evening to allow me to place upon record the great loss that this Society, and the geological world in general, have sustained in the death, on the 14th October last, in the 69th year of his age, of our highly distinguished honorary member, Dr. Thomas Davidson, F.R.S., of Muirhouse, Midlothian, at his residence, 9 Salisbury Road, West Brighton.

Dr. Davidson was elected the first honorary member of our Society in 1859, the second year of its existence. It was in the year 1856, when he began to gather material for his monograph on the Carboniferous Brachiopoda of the British Isles, that the members first made his acquaintance. Previous to this he had completed between the years 1851 and 1854 the first quarto volume of British Brachiopoda for the Palæontographical Society, comprising the Tertiary and Secondary species. At that time I was residing at Lennoxtown, Campsie, and Dr. Davidson wrote to see if I could assist him by the loan of Scottish Carboniferous Brachiopoda from my own collection, and by giving him the names of other collectors whom I knew to be possessed of specimens.

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This I was very willing to do, and the correspondence then opened up only closed with death, his last letter being dated 8th October, 1885, the week before his decease. During this long interval of twenty-nine years very many letters had passed between us, and all relating to his great work above mentioned. It makes me sad to find that of the ten individuals he thanks for assistance in the preface to the Carboniferous monograph, dated June, 1857, and whom he styles his "Scottish friends and countrymen," I am now the only living representative.

After coming to my present post in Glasgow, in 1859, I pressed upon Dr. Davidson the importance of preparing a short descriptive monograph of the Scottish Carboniferous Brachiopoda, with plates, and this he kindly consented to do, having in the meantime been elected an honorary member of our Society, an honour which all his life he highly appreciated.

This monograph of the Carboniferous Brachiopoda of Scotland is a very valuable little work. It appeared in the "Geologist" (now the "Geological Magazine") during the years 1859, 1860, with the following title:—"The Carboniferous System of Scotland, characterized by its Brachiopoda. By Thomas Davidson, F.R.S., F.G.S., Honorary Member of the Geological Society of Glasgow," etc., etc. In the introduction reference is made to the many eminent Scotchmen who have "contributed to elevate the science of Geology to the rank it now holds among all men of learning"; and it further states, that, "Much has however still to be achieved before the geological and palæontological details connected with our country will have been completely worked out." "I therefore hailed with much hope and delight the foundation of a Geological Society in Glasgow, which originated in May, 1858, with about a dozen young men, who wished to gain knowledge of the geological phenomena in the neighbourhood of their great city." "The Society has already done some good work, and increased its numbers to about one hundred." The author further refers to the palæontological riches of some of our rocks, and says—"I here attempt the publication of a special illustrated catalogue or monograph of all the Scottish species of Brachiopoda that have been hitherto obtained from the strata of the Carboniferous period; and this I have undertaken in the hope that by so doing it may stimulate and facilitate further researches, as well as prove of some assistance to those friends in Scotland to whom I am per-

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sonally indebted for the gift and loan of the valuable series of specimens which will be made use of in the present memoir."

In the year 1868 he also prepared a quarto paper of twenty-one pages, with three plates of figures, on the "Upper Silurian Brachiopoda from the Pentland Hills." This was printed, and was intended to form the first part of a projected palæontological series on Scottish fossils, to be issued by a committee of members of this Society, but the scheme was never further carried out.

During the long series of years that Dr. Davidson was engaged upon his great work on the Brachiopoda he was a hard worker and methodical investigator, grudging every day that he could not devote to it. He generally worked from six to eight or even ten hours per day, and at one period he wrote me often that he was very much afraid his health and sight would break down from the long-continued strain before he had finished on the stone all the plates for his monograph. The desire to see this great work completed was his constant aim during the later years of his life, and, happily, with care, this wish was accomplished. He had a warm regard for everything Scottish, and often in his letters he expressed a desire to visit "dear old Scotland" more frequently than he was able to do, but it was very seldom that he ever was tempted to tear himself away from his engrossing work. On one of his visits to his estates in Midlothian, he came for a day and night to Glasgow, and was entertained to dinner by members of this Society in one of the hotels of the city. This was in the year 1863 or 1864.

After having finished his series of monographs on the Brachiopoda of the several British formations in 1871, he again returned to the work in a series of supplements, in which he figured, and described, all the additional species or varieties that in the interval had been discovered, or of which better preserved examples had been found. It is in these supplements that he was enabled to do full justice to all that had been discovered in Scotland in the strata of the Carboniferous and Silurian formations, and it is here that was found the full value of the special Carboniferous monograph to which I have already referred, as members of this Society were thereby enabled to add to its list of Scottish Carboniferous Brachiopoda all the later discovered species. In the introduction to his Supplement of Carboniferous forms, p. 249, he states that "eleven other species had been

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discovered, described and illustrated, that were either new to science or new to Great Britain." In the same interval of time eight species were added to the Irish list, while none were added to the English.

It gave Dr. Davidson the utmost pleasure to be able to illustrate so many genera and species of Brachiopoda from the Silurian strata of the Girvan district, the result of the careful collecting of Mrs. Robert Gray and others. At p. 220 of his Silurian supplement he sums up all the Scottish species of Brachiopoda which had come under his observation from the several formations, including the Recent period. These are, in all, as follows:—4 Recent, 2 Post-tertiary, 17 Liassic and Oolitic, 59 Carboniferous, and about 134 Silurian species, making a grand total of 216 so termed species. "This," he says, "is a large number from a country that had been so long considered as scarcely fossiliferous in this respect. And when it is borne in mind that it is only from the Jurassic, Carboniferous and Silurian formations that Scottish Brachiopoda have been obtained, the number of species is certainly remarkable."

During the preparation of Dr. Davidson's later supplements he kindly asked me to examine for him the microscopic shell-structure of several of the genera and species of the perforated Brachiopoda from the Carboniferous and Silurian formations. This I did from time to time, and sent him the specimens operated upon, with my notes of remarks. These interested him so much that he has done me the honour of printing in his great work my notes on what I had discovered, and of stating that my researches had revealed in some cases points of structure not formerly known, and in others structures only briefly noticed, and very imperfectly described.

Dr. Davidson completed the last supplement to his series of monographs in 1884, having been nearly thirty-four years engaged on the work. It forms a bibliography of all the papers known to have been written on this group of the Mollusca, from the first notice in 1606 down to the date of the publication, and fills one hundred and sixty-three quarto pages. This bibliography he considered an important piece of work, the materials for which he had been collecting for years, and he told me that as it had cost him a great deal of time and research, he hoped it would be of use to all subsequent investigators of the Brachiopoda by

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acquainting them with what had already been written on the subject.

During the long series of years in which Dr. Davidson was engaged in describing and illustrating the fossil Brachiopoda, he at the same time was quietly assembling a collection of the Recent forms from all the seas of the world where they could be obtained. Of all the species of these he had already drawn illustrations ready to be placed on the stone for printing, and had likewise written out the necessary descriptions. They will fill a large quarto volume, which he had arranged, previous to his decease, should be printed for the Linnean Society of London, of which he had long been a distinguished member.

Having stated thus much regarding Dr. Davidson's life-work, and especially his work in connection with the Geological Society of Glasgow, and the Scottish fossil Brachiopoda, I will now only refer those who wish a fuller sketch of his scientific career to an article in the "Geological Magazine" for April, 1871, entitled, "Eminent Living Geologists: Sketch of the Scientific Life of Thomas Davidson, F.R.S., with portrait." In that sketch they will learn that upwards of thirty scientific societies, all over the world, did themselves the honour of placing his name on their list of honorary members. Also, that up to that date, he had written no less than some forty-nine distinct works or papers on the Brachiopoda, which fill some 2,220 pages, accompanied by 244 plates of figures, all drawn and placed on stone ready for the printers by his own hands. Surely such long-continued industry, coupled with so much talent and enthusiasm, may well call forth the highest esteem and admiration for our departed honorary member. I therefore take the liberty of moving, that we as a society instruct our Honorary Secretary to write to Mrs. Davidson and family, expressing our sympathy with them in their bereavement, with the feeling of loss that this and kindred societies have sustained in the death of our lamented friend Dr. Davidson.

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No. XI.—Notes on the Carboniferous Brachiopoda of Scotland, with a revised list of the Genera and Species. By John Young, F.G.S., *V.P.*

[Read 11th March, 1886.]

In the present paper I offer a report to the Society on our present knowledge regarding the genera of Carboniferous Brachiopoda found in Scotland, with remarks on their shell-structure and other external and internal characters; also a revised list of the Scottish species, as determined by the late Dr. Davidson and printed in vol. 5, part 3, of his "Monograph of the British Fossil Brachiopoda," for the Palæontographical Society, London, 1884.

During the period of time embraced in the researches of Dr. Davidson, in connection with this monograph, extending from 1851 to 1884, an immense amount of knowledge has been gained not only of the genera and species of the Brachiopoda found within British strata, but likewise of those found in other countries of the world, as well as of those still living in recent seas. In the preface to the first volume of his work, 1853, Dr. Davidson writes thus of the group:—"Of all the species composing the sub-kingdom mollusca, none are, perhaps, more varied, more elegant in shape, or more abundantly distributed than those to which the term Brachiopoda or Palliobranchiata has been applied. They are found in the oldest deposits at present known to contain vestiges of animal life, and have continued to exist, some in similar, but many under different shapes to the existing forms, through the long successive periods which lead to the present time. Their full value to the geologist is consequently very great; and, as they so frequently fall under his hammer where other classes are often but sparingly represented, they must therefore be looked upon as excellent data for the age of the deposit; for, although some few individual forms pass from one stage to the other, the generality are limited to defined horizons."

It was not until 1857 that the British Carboniferous Brachiopoda came to be taken up by Dr. Davidson.* At that time the whole group existed in a state of great confusion and in a badly determined condition both as to genera and species. You will better understand this confusion and multiplication of names from what

* Second volume of the work.

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Dr. Davidson states.* "At the time I commenced my researches, about 260 so-termed British Carboniferous species of Brachiopoda had been recorded by different palæontologists; but, after a most searching investigation, I could not conscientiously admit more than about 100 of these, and in order to arrive at such a reduction no small labour was required, nor was I unmindful of the danger palæontologists should guard against in the breaking down of species, which, if injudiciously done, would be as great an evil as that of uselessly multiplying them." He further states, in the same page, that Professor Morris, in his "Catalogue of British Fossils, 1854," had recorded 193 species of Carboniferous Brachiopoda, of which he had retained only 93. Professor Phillips had enumerated 100 species as found in Carboniferous strata in England, of which he had retained only 52; while of 250 species recorded by Professor M'Coy and Mr. Kelly from the same formation in Ireland, he says:—"My most strenuous efforts have not shown the existence of more than about 80."

In Scotland at that time comparatively few Carboniferous Brachiopoda had been recorded. For the British Association meeting at Glasgow in 1855 I prepared a MS. catalogue of the Carboniferous fossils from Western Scotland, then exhibited to the members. In the list of Brachiopoda there were 43 named and 14 unnamed species, in all 57 species. Of the 43 named species only 23 are retained in Dr. Davidson's revised list, the rest being held as only varieties, or have since been more correctly determined to belong to genera and species not then known to have been found in Scotland. During the preparation of Dr. Davidson's monograph of Carboniferous species, and since its completion in the supplementary volume, the list of Scottish species has been very much increased, chiefly through the efforts made by members of this Society, in the careful exploration of all the strata known to yield Brachiopoda and other marine forms; and the revised list now shows † that there have been found in Scotland 59 species and 17 named varieties, several of the latter being now held to be good species, and given as such in the concluding volume of the monograph, 1884. These are now found to belong to 19 distinct genera, instead of some 7 genera, the number amongst which the group was formerly divided. Dr. John J. Bigsby, in his "Thesaurus

* "Carboniferous Brachiopoda," p. 211.

† Carboniferous Brachiopoda, Supplement, pp. 257-261.

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Devonico-Carbonarius, 1878," gives a list of the species of Carboniferous Brachiopoda from the various countries of the world recorded up to that date, and numbering 939. Dr. Davidson, in remarking on this list, says* :—"Out of this number I find that some 143 species and a few named varieties have been described by myself from Great Britain. Although the total number of 939 will no doubt have some day to be very considerably reduced, still it will show how numerous and varied were the species of Brachiopoda that lived during the Carboniferous period, and especially so during the deposition of the Limestone series and its accompanying Shales."

In my remarks on the genera of Carboniferous Brachiopoda found in Scotland, I shall follow the arrangement given in Dr. Davidson's revised lists, in which the Tretenterata precede the Clistenterata, these being the two groups into which the Brachiopoda are now arranged by zoologists according to their internal organization.

Tretenterata.

Lingula.—This interesting genus, forming one of the oldest and most persistent types of the Brachiopoda which have descended to us from the earlier fossiliferous formations, is represented in the Carboniferous strata of Scotland by four species, of which only two are common, viz., *L. squamiformis* and *L. mytiloides*. These are found to range from the lower Calciferous sandstone series, up through the several divisions of the limestone strata, into that of the millstone grit and upper coal-measures, while *L. mytiloides* seems to have lived on into Permian times, in which formation it is known as *L. Credneri*. In the purer beds of limestone in the Scottish coal-fields, *Lingula* is rare, but it abounds, especially *L. squamiformis*, in certain of the shales which alternate with the limestone series. In the Glasgow coal-field, in the group of lacustrine strata embracing the lower coals and ironstones which lie between the lower and upper limestones, the two species above-named are often seen to crowd certain horizons of black, carbonaceous shales, having flourished apparently under conditions of water not favourable to the growth and development of any other marine organisms. On one of these horizons, viz., that overlying the lower Possil ironstone at Keppoch, north of Glasgow, *L. squamiformis* attained a size of one inch and a half in length, examples being figured by Dr. Davidson in his monograph as

* Carboniferous Brachiopoda, Supplement, p. 253.

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the largest he had seen from British strata. On another, higher horizon, in the same group of strata to the north of Glasgow, on the sinking of a pit at Robroyston, to the upper Possil ironstone, there were found numerous examples of *L. squamiformis* and *L. mytiloides*, which were standing erect in the strata in the position they had lived and died in and with their valves united. So finely were their surfaces preserved that Dr. Davidson stated in a letter to the author, that they were the best preserved fossil *Lingula* he had ever seen. So abundant are *Lingula* in other portions of the Lanarkshire coal-field that the late Dr. Rankin, of Carluke, in his table of the strata in that district, designates two beds in the series as the *Lingula* limestone and the *Lingula* ironstone.

The shells of *Lingula*, and those of *Discina* next to be noticed, differ in their mineral composition from those of most of the other genera of Brachiopoda in being corneous, or having a horny or chitinous structure. This character serves to distinguish them from other shells, even when they occur as fragments. Specimens of *L. mytiloides* from Scotch strata, showing remains of colour markings, have been described by Mr. Robert Etheridge, jun., and by myself. This shell is also often found with a fine bluish tint in the East Kilbride beds.

Regarding the other two Carboniferous species found in our strata, *L. Scotica* and *L. Thomsoni*, I have only to remark that both are rare. *L. Scotica* is a large species and is remarkable for its triangular shape. It was first found by Dr. Rankin in the Gare limestone shales, Carluke, and by Dr. Slimon in two localities in Lesmahagow parish. I have also found it in the Boghead shales near Hamilton; and more recently Dr. Davidson has figured one or two large and fine examples from Redesdale, in Northumberland.* *L. Thomsoni* is only as yet known from Carboniferous limestone strata, in Tirfergus Glen near Campbeltown, where it was discovered by Mr. James Thomson. I have very great doubts about this shell belonging to the genus *Lingula*. It shows no trace, in the examples that I have examined, of that peculiar horny appearance of the shell so characteristic of other species of the genus. Dr. Davidson, in his description, says nothing about the structure of the shell, beyond that it is "longitudinally and finely striated," and that he had only "seen two examples." One of my two specimens

* Carboniferous Brachiopoda, Supplement, pl. xxx.

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shows the striæ on the surface, but they both show what is not seen in *Lingula*, viz., that the beak is slightly turned to one side, as is often found in Lamellibranch shells, so that its appearance is more like that of *Posidonomya* than *Lingula*. This being the case, and the apparent absence of the corneous shell, incline me to place a point of interrogation against the generic name in the list, until its shell-structure is further examined in other specimens.

Discina.—This genus is represented in Scottish Carboniferous strata by two species, only one, *D. nitida*, being common and found ranging from the marine beds of the Calciferous sandstone series up to those of the higher coal-measures in the Lanarkshire coal-field. It is also believed to be identical with one of the species found in the Permian strata of England, where it is known as *D. Koninckı*. It is rather a rare shell in most British localities, but in one or two horizons of the Scottish coal-field, in some of the limestone quarries, examples may be picked up by the hundred on the banks of weathered shale. One of these is the bed of shale separating Nos. 1 and 2 limestones of the Calderwood series, in the parishes of Blantyre and East Kilbride, where this species is found in excellent preservation and often of a larger size than elsewhere. The surface of the shell, like that of *Lingula*, as formerly stated, has a corneous or horny lustre, and is often met with of a bluish colour. Dr. Davidson has figured an example from these beds showing radiated, bluish colour-markings still remaining on the surface of the shell, and he has also been able to illustrate the interior of the valves from other specimens.

The other Scottish Carboniferous species, *Discina Craigii*, is rare. It was discovered by Mr. Robert Craig, of Langside, Beith, corresponding member of the Society, in the lower limestone series of the Dockra Quarry, Beith. Two examples were found, one of which is figured and described by Dr. Davidson as *D. Craigii*, Davidson.* It measures one inch eight lines in diameter and is the largest species of the genus that ever came under Dr. Davidson's examination. Subsequently another example of this shell, one inch and three-quarters in diameter, was obtained by Mr. James Neilson from a cutting of the Union Railway, north-east of Glasgow, in a bed of sandstone containing marine shells, lying close on the horizon of the upper limestone with the millstone grit series of

* Carboniferous Brachiopoda, Supplement, pl. xxx., fig. 14.

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that district.* This species is not known from any other locality in our strata.

Crania.—The shells of this genus are often seen to assume various shapes, according to the form of the surface to which the lower valves are attached, but on the whole they have varied little in external form from their first appearance in the fossiliferous strata down to the present time. In the Carboniferous rocks of Scotland the genus is represented by only one species, *C. quadrata*, which is seemingly restricted to the strata of the lower and upper limestone series. In Scotland, as well as in England and Ireland, it is rare on most horizons, but in the shale of the Calderwood limestone series it is specially abundant, as at Capelrig Old Quarry, East Kilbride, where it is found clustered upon shells and stems of crinoids in a very interesting way. I possess a stem of a crinoid two inches long and one half inch in diameter on which there are remaining no fewer than sixteen examples of the lower or attached valve. These are seen to be, in some instances, so close together that the edges of shells, where they impinge upon one another, have often interfered with their shape and regular growth. Very good examples of the interior of the valves are found in this horizon, and from those Dr. Davidson has been able to illustrate the muscular impressions. The shells of *Crania* differ from those of *Lingula* and *Discina* in being calcareous, and when well-preserved, the upper or free valve is found to be minutely perforated, as is the case in many other genera of Brachiopoda. In the lower valve I have found no trace of perforations, and was therefore led to examine the lower or attached valve of *C. anomala*, the only living British species. I found in it very few visible perforations compared with those to be seen in the free valve, although it has been supposed that both valves were perforated alike. Had the lower valve of *C. quadrata* been perforated to any extent I could hardly have failed to have observed the fact in some of the numerous specimens I have examined, especially as in those specimens the perforations of the upper valve are well seen.

Clistenterata.

Dielasma (*Terebratula*).—The researches made during recent years into the internal characters and other points of structure in that extensive group of the Brachiopoda which now forms the family

* *Transactions*, vol. v., p. 227.

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of the Terebratulidæ have led to the formation of several sub-genera. The *Terebratula* of the Carboniferous and other palæozoic strata are now placed in the genus *Dielasma*, of King, from their possessing septal and dental plates within their shells. According to Dr. Waagen (whom Dr. Davidson quotes in regard to these new sub-genera of the Brachiopoda), the genus *Dielasma* appeared first in the Devonian and continued up through the Carboniferous and Permian formations into the lower Trias, where it seems to have become extinct, and to have been replaced by another type or sub-genus of *Terebratula*. In Scottish Carboniferous strata, *Dielasma* is represented by four species which were at one time considered by Dr. Davidson to be only varieties of one type, *D. sacculus*, Martin; but in his revised list they now rank as species. One of these, *D. hastata*, is found in strata of the Calciferous sandstone series in the East as well as in the West of Scotland, but it is in the strata of the lower and upper limestones that they have been found most frequently, although they are everywhere rather rare shells.

None of the Scottish examples ever seem to have attained a length of more than one inch, and this dwarfed condition is also characteristic of several of the other genera of the Clistenterata found in Scotland, when compared with the larger and similar forms from the Carboniferous strata of England and Ireland. In the limestones and shales of the Beith district, as well as in those from the Brockley district, there are found numerous examples of a small race of *Dielasma*, chiefly *D. sacculus*, few exceeding one-fourth of an inch in length, while many are less than a line in diameter. The perforations characteristic of the shell-structure are often well preserved, especially in examples found in shales, and this character enables the genus to be easily recognized, even in strata where the shells are frequently found in a crushed and fragmentary condition. Specimens showing the interior of the valves are sometimes found in these shales, but they are very rare.

Spirifera.—This genus, which forms the type of the family Spiriferidæ, has now been divided into several sub-families and sub-genera, some of which fall here to be noticed. Of ten species of *Spirifera* recorded from the Carboniferous strata of Scotland in Dr. Davidson's former lists, only five are now retained, one found at Gillfoot, Carluke, a single valve of *S. triangularis*, in the late Dr. Rankin's collection, being, however, very doubtful. This speci-

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men appears to me to be only a portion of the extended hinge-area of a rather wide example of *S. trigonalis*, such as is found in the shale of the same locality. This last-mentioned species and its variety, *S. bisulcata*, are by far the most widely distributed members of the genus within the coal-fields of Scotland, ranging from the Calciferous sandstone series up into the strata of the lower and upper limestones. *S. trigonalis*, the type species, presents us with several interesting and well-marked varieties, to which I formerly called attention in a paper read to the Glasgow Natural History Society, * noticing their vertical range and distribution within our coal-fields. I have also, in a more recent paper "On the denticulated structure of the hinge-line of *S. trigonalis*," † described the interesting character which, in specimens derived from our limestone shales, I discovered in connection with the hinge-area of this species. This character is also figured and described from the same specimens by Dr. Davidson in his Monograph, ‡ and in those notices fuller information regarding them may be had.

Martinia (*Spirifera*).—The species forming this sub-genus are now characterized by having a minutely perforated shell-structure, whilst those of *Spirifera* proper are not known to be perforated. This perforated character, as pointed out by Dr. Davidson, was not known to Professor M'Coy, when, in 1844, he proposed the genus *Martinia* for some of the *Spirifera* now there placed, doing so on the mistaken supposition that their spiral appendages were small, although Dr. Davidson has since shown this is not the case. There are amongst Scottish specimens of the genus very few examples which now show any trace of those minute perforations, but this is believed to be due to alteration of the shell-structure from fossilization. Dr. Davidson states that according to Dr. Waagen the punctured epidermis seems to be more easily destroyed in the shell of the true *Martinia* than in those of the sub-genus *Martiniopsis*, in which it is much better preserved and therefore more frequently found. Since that period I have discovered perforations in *S. ovalis*, which is closely allied in form to the genus *Martinia*, and is now placed with it in the list of species. On communicating this fact to Dr. Davidson, he wrote, Jan. 26th, 1885: "I am glad that you have found perforations in the shell of

* *Proceedings*, vol. iii., p. 373, 1876.

† *Geol. Mag.*, decade iii., vol. i. 1884, p. 18.

‡ Vol. v., part iii. 1884, p. 373.

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Spirifera, or rather now *Martinia ovalis*. It did not surprise me to learn that you had found them, and I think it is quite right to separate the perforate from the non-perforate species." The specimen showing these perforations is a finely-preserved though small example from the limestone shales of the Brockley district, and I hope this structure will yet be found in other specimens.

On many Scottish examples of *Martinia Urei* (formerly *Spirifera Urei*), besides the covering of minute spines on the surface of the shell, which was first illustrated by Dr. Davidson from Scottish specimens, there is to be seen a beautiful reticulated ornamentation confined to the inner surfaces of the valves and the surfaces of casts. I have also found this structure in other Scottish Carboniferous Brachiopoda, and as it might be mistaken by some to be a kind of perforation of the shell-structure, I may explain that it is due to the cropping out on the inner surfaces of the valves of the bundles of shell-fibre which compose the structure of the shell, and which, in their oblique or inclined passage through its thickness, produce the imbricated arrangement of the ends of the bundles spoken of. This structure has been examined by the late Dr. Carpenter and others in recent Brachiopods, and examples of it are illustrated by Dr. Davidson in his monograph. *

Reticularia (*Spirifera*).—In Dr. Davidson's lists this sub-genus is represented from British Carboniferous strata by only one species and two named varieties. The genus extends from the Devonian up into the Carboniferous limestone series, and in Scotland is found ranging from the Calciferous series into the lower and upper limestones, but it is not very abundant in any of its localities.

The genus *Reticularia* was first proposed for this species and its varieties by Professor M'Coy in 1844, from the reticulate markings seen on the surface of the shell, but the name was not then adopted by palæontologists. It has, however, been revived by Dr. Waagen, and is now accepted by Dr. Davidson, owing to the discovery on the shell-surface of new characters, only recently observed, and not known to M'Coy or Davidson. These new characters were first noticed in 1880, and are now figured and described by Dr. Davidson in his monograph,† and may here be shortly mentioned,

* Vol. i., parts v. and vi.

† Carboniferous Brachiopoda, Supplement, vol. iv., pl. xxxiv., fig. 9, p. 275.

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as consisting of a series of barbed spines, arranged in concentric lines, upon the surface of both valves. These spines were hollow, and consisted of two tubes, as in a double-barrelled gun, which ended in two small pores on the surface of the shell. The bases of these spines have produced the reticulations on the surface from which the genus now takes its name. The hooklets on the spines are arranged in two parallel rows, and their points are directed towards the free ends of the spines, or away from the shell. This structure I first discovered in a specimen from the Blantyre shales, and I have since observed it in examples from other localities. The characters here noticed have not yet been observed in any other Brachiopod shell, recent or fossil. I have also found, in a specimen from the Brockley shales, that this genus is further characterized by having a minutely perforated shell-structure, as in *Martinia ovalis*.

Spiriferina.—This genus is represented by four species in the Carboniferous strata of Scotland. The most common species, *S. cristata*, variety *octoplicata*, is found in certain of the marine beds, ranging from the Calciferous series up into the lower and upper limestones. Another species, *S. Etheridgei*, Dr. Davidson found at Fullarton quarry, near Temple, Midlothian, in the lower limestone, and it has not yet been identified from any other locality in Britain. None of the species are common in any of the localities in which they are met with. They are readily recognized from species belonging to the true *Spirifera* by their strongly perforated shell-structure.

Athyris.—Four species belonging to this genus have been found in Scotland. One of these, *A. pisum*, Davidson, a small form got by Mr. James Thomson in the lower limestone shales at Brockley, has not yet been met with in any other locality. The most abundant species, *A. ambigua*, seems also to have had the greatest vertical range, being found in strata extending from the marine beds of the Calciferous series up into those of the lower and upper limestones. Several varieties of this species are found, and are well illustrated in Dr. Davidson's monograph. Another species, *A. Royssii*, is also moderately common in the lower limestone shales of the Beith and Brockley districts, where specimens may be picked up, showing the numerous concentric rows of flattened spines which completely covered the surface of the shell, and so characterize this species. The shells of the genus *Athyris* are not

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known to be perforated in their structure, and may thus be known from shells belonging to the Terebratulidæ, but the fibrous bundles of their shell-structure sometimes form a reticulate ornamentation on the surface of casts, similar to that which I previously pointed out was seen on the casts of the shells of *Martinia Urei*, Fleming, and which might be mistaken for perforations.

Retzia.—This genus is the only other member of the Spiriferidæ yet found in Scottish Carboniferous strata, and is represented by only one species, *R. radialis*, which is found in both the lower and upper groups of limestones. It is a small shell, and is rare in all its localities, but may be known from shells of *Rhynchonella*, which it externally resembles in its form and ribbing, by having a minutely perforated shell-structure as in the Terebratulidæ.

Rhynchopora.—The shells of this genus externally resemble those of the Rhynchonellidæ, but are distinguished from them by having a perforated shell-structure. Only two species of the genus are yet known, one being from strata of the Permian formation in Russia, the other from the Carboniferous strata of the Beith and Dalry district in Ayrshire. At Bowertrapping there, where it was first discovered, it sometimes occurs in abundance in a gregarious condition in certain portions of the limestone, but is rare or absent in other parts of the bed. It has not yet been recorded from any other British limestone strata.

Camarophoria.—This forms another genus of the Rhynchonellidæ, and is represented in Scottish Carboniferous limestones by two species, both rare, and only recorded from the lower beds. Externally the shells strongly resemble *Rhynchonella*, and I have no doubt that specimens may exist in collections under that name. They may be distinguished from shells of that genus by their converging dental plates, and by one or two other internal characters, which are rarely visible on the surface of the shells, but may be exposed by etching them with acids.

Rhynchonella.—This genus, the type of the family Rhynchonellidæ, is represented in Scottish strata by three species, one of which, *R. pleurodon*, ranges from the marine beds of the Calciferous series up into those of the lower and upper limestones, but in the later deposits it became rarer, and generally of smaller size. *R. pugnus*, on the other hand, is more common in the later

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deposits than in the earlier beds. The third species, *R. Brockleyensis*, Davidson, was found by Mr. James Thomson in the lower limestone shales of the Brockley district, where it is a rare shell, not having yet been recorded from any other locality in the strata of the Scottish coal-fields. I may here mention that the largest and finest examples of *R. pleurodon* I have yet seen from the strata of the West of Scotland are found in a bed of shale underlying the coralline limestone band at Corrieburn on the Campsie hills, but even there it is only about half the size of some of those from the English limestones.

Orthis.—This genus, forming one of the three members of the family Strophomenidæ found in Scottish Carboniferous strata, falls here to be noted. Though extremely abundant in species in the strata of the Silurian period, this genus is represented in British Carboniferous strata by only four species, one of which is doubtful. In Scotland two of the four species are found, one being *O. resupinata*, which ranges from the Calciferous series up into the lower and upper limestones, but is only moderately common in any of the localities. *O. Michelini*, the other species, is abundant in some of the strata of the lower limestones of the Beith district, where fine examples may be picked up showing the outer covering of spines, and the muscular impressions in the interior of the shell. The shell-structure of the genus is minutely perforated, that of *O. Michelini* showing perforations of various sizes. Dr. Davidson figures and describes * what he terms a small variety of *Orthis resupinata*, with widely separated beaks, from Corrieburn, Campsie. This form is, I think, more closely related to the one he has figured as *O. Keyserlingiana*, De Koninck, than to the former species, although placed provisionally with it, but is probably a distinct species from either.

Streptorhynchus.—This genus is represented in Scottish Carboniferous strata by one species and three named varieties. *S. crenistria*, the type form, is found ranging from the Calciferous series into the upper limestones, and is extremely abundant in certain districts, as at Auchenskeoch, Dalry, from which locality Dr. Davidson in his Carboniferous monograph has figured examples, which measured from five to six inches in width, by three and a half inches in depth, being the largest yet found in British strata. The varieties of this species found in Scotland are more

* Carboniferous Brachiopoda, pl. i., fig. 15.

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rare, and more local in their distribution than the type form, some being confined to certain horizons of the upper limestone. In my examination of the shell-structure for Dr. Davidson, I found that the perforations were confined to the inner layers of the shell, and presented the same characters as those seen in shells of the family Productidæ.

Strophomena.—This genus appears to be represented by only one species and one named variety in the Carboniferous strata of Scotland. It is rather a rare shell, and has only been met with in strata of the lower and upper limestone groups. The perforations are confined to the inner layer of the shell, and are somewhat widely apart, lying in an inclined and slanting direction towards the beak. The most interesting and noticeable character observed in connection with Scottish examples of *Strophomena analoga* and its variety *Strophomena distorta*, and which Dr. Davidson was never able to explain, is the way in which the vascular impressions on the interior of the shell are seen to radiate in a continuous manner from the beak all over the inner surface, instead of forming a ring around the ovarian spaces, as had been already figured and described by Professor King and Dr. Davidson from examples found in the English Carboniferous limestone. Examples showing this peculiarity in the Scottish specimens were found in the Main limestone at Campsie and at Bowertrapping, near Dalry, one being figured by Dr. Davidson.*

Productus.—Of all the genera of Carboniferous Brachiopoda found in Scotland, none so abundantly represents the group as that forming the family Productidæ, Dr. Davidson identifying no less than twenty-five species, including one or two named varieties. From the whole of the Carboniferous strata of Britain some forty species have been obtained, but this list includes also one or two named varieties. From the abundance of certain species in the strata of the Scottish coal-fields, some of the beds are known as the *Productus* limestone and shales. The genus ranges from the lower beds of the Calciferous series into that of the lower and upper limestones, millstone grit, and upper coal-measures, becoming, so far as known, extinct in the strata of the Permian formation. Whilst many of the species of *Productus* are very abundant in all the strata in which they are met with, others are very rare, being confined to a few localities and to certain horizons.

* Carboniferous Brachiopoda, Supplement, pl. xxxvi., fig. 23.

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The places where these have been chiefly found are noted in the "Catalogue of Western Scottish Fossils," Glasgow, 1876, and need not here be repeated. The most important characteristic noted by Dr. Davidson in connection with Scottish specimens of this genus is the light which they enabled him to throw upon the internal muscular impressions in the shells of many of the species, and also of the spines which were once adherent to their surfaces. These specimens were chiefly obtained from the shale beds and from the rotted limestones, and will be found illustrated in the Carboniferous monograph as well as in the later Supplement to it. While Dr. Davidson was engaged in his investigation of the group, I was also privileged to prepare for him examples of nearly all the Scottish species, to show the nature of the shell-perforations. Previous to this period very little was known of the shell-structure in *Productus*, and the work proved of greater interest than either of us anticipated when first taken up. We found that whilst the perforations in the shells of the Productidæ were all on a similar plan—confined to the inner layers of the shell and not passing to its external surface—yet they varied much in character in the several species. Some of these structures are illustrated by Dr. Davidson in the Carboniferous Supplement,* and the species examined are described in the text. I have only further to mention in connection with *Productus* that an esteemed member of this Society, Mr. James Bennie, of the Geological Survey of Scotland, discovered at Skaterow Harbour and East Barns Quarry, near Dunbar, in the lower limestone series, a species of the genus which was adherent by its spines and often by one of its valves to crinoid stems, shells, and fragments of polyzoa. This very interesting form has been illustrated, described and named *Productus complectens* by Mr. Robert Etheridge, jun.† I have also to note the finding of a specimen of *Productus scabriculus* with a broad-margined fringe or band of about three-eighths to five-eighths inch in width around the outer edge of the shell. This character has sometimes, but very rarely, been noticed in connection with other species of the genus. The specimen in question I found in the limestone at Hillhead Quarry, Beith, Ayrshire.

* Plate xxxvi.

† *Quarterly Journal of the Geological Society*, vol. xxxii., pls. xxiv-xxv. The description and figures are also reproduced in Dr. Davidson's Carboniferous Brachiopoda, Supplement, pl. xxxv.

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Chonetes.—This genus is represented by four species in Scottish Carboniferous strata, and ranges from the Calciferous series into the lower and upper limestones. It is rare in the purer limestone beds, but in the alternating shales one or two of the species are abundantly met with in several localities in Scotland. The largest and most widely distributed species, *Chonetes Laguessiana*, is found in fine preservation in the shale which separates the Nos. 1 and 2 limestones of the Calderwood series, in the parishes of Blantyre and East Kilbride, Lanarkshire. From this horizon I have been able to examine the shell-structure of *Chonetes* in specimens of this species for Dr. Davidson, and it will be found figured and described in the Appendix to his Supplement.* Previous to this examination little or nothing was known of the true nature of the perforations in *Chonetes* nor of the passages of the tubular spines on the hinge area of the ventral valve as pores which open to the interior of the shell. I was therefore much pleased to be able to reveal these structures in Scottish specimens, and to find that they closely agreed with those I had previously found in the Productidæ.

Aulacorhynchus.—This genus, the last in Dr. Davidson's list of Carboniferous Brachiopoda found in Scotland, is represented by only one species, *A. Davidsoni*, and was obtained from the limestone at Clatteringwell Quarry, Bishops' Hill, Kinnesswood, Kinross-shire, the specimens now being in the Museum of Practical Geology, London. This shell at first was doubtfully identified by Dr. Davidson as belonging to *Chonetes concentrica*, De Koninck, and is figured and described by him as such in the Appendix to his Carboniferous monograph.† In the Appendix to Supplements,‡ Dr. Davidson again refers to this shell, and states that it also had been found, along with other species of *Aulacorhynchus*, in the Asturias, a province of Spain, and that the Scottish form had received the name of *A. Davidsoni*, Barrois. The genus is also found in American Carboniferous strata, but since Dr. Davidson described the shell no other examples seem to have been found in Scotland or elsewhere within the British Isles.

I have only further to remark before concluding these notes that there is not much likelihood of the list of genera and species

* Vol. v., pl. xx., pp. 280-283.

† Vol. ii., p. 278, pl. lv., fig. 13. ‡ Vol. v., p. 283.

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of the Brachiopoda being much further increased from Scottish Carboniferous strata. Still, there is reason to hope that, as new localities are opened up, some of the Carboniferous forms found elsewhere in Britain may yet be found within the area of our coal-fields. There is, however, more important work still to be done amongst this class of organisms than the finding of new genera and species, and that is, in trying to discover amongst certain of the genera better preserved examples of the species showing the internal muscular impressions and other interior characters; likewise, in trying to discover in the more perfectly preserved examples of other species what were the external characters on the surface shell, as also the nature of the perforations, where such exist, in the shell-structure. Already Dr. Davidson has been able to throw much light on some of these points from the study of Scottish specimens, which often have their shell-structure better preserved than in examples obtained from the English and Irish limestones, in which the shells are found to be often much altered by crystallization or other metamorphic changes.

In preparing the following list of genera and species of the Carboniferous Brachiopoda found in Scotland, I have consulted for the Calciferous division of the strata the list given in Dr. Bryce's "Geology of Arran";* the papers of Mr. Robert Etheridge, jun., "On Lower Carboniferous Invertebrata";† and that of Mr. J. W. Kirkby "On the Zones of Marine Fossils in the Calciferous Sandstones of Fife."‡ For those of the lower and upper limestone strata, millstone grit, and upper coal-measures, I have consulted the lists in Dr. Davidson's monograph, "Catalogue of Western Scottish Fossils," "Explanations of Sheets 23 and 31 of the Geological Survey Map, Geological Survey Memoirs, 1873-1879," and the various papers in the *Transactions* of this Society which contain lists of Carboniferous Fossils.

* Fourth edition, 1872, p. 225.

† *Quarterly Journal of the Geological Society*, 1878, vol. xxxiv., p. 23.

‡ *Ib.*, 1880, vol. xxxvi., p. 588.

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REVISED LIST OF

SCOTTISH CARBONIFEROUS BRACHIOPODA, 1885.

GENERA AND SPECIES.	Calciferous Sandstone Series.	Lower Carb. Limestone Series.	Upper Carb. Limestone Series.	Millstone Grit Series.	Coal Measures.
TRETENTERATA.—*King.*					
Lingula mytiloides, Low.	x	x	x	x	x
,, *squamiformis*, Phill.	x	x	x	x	x
,, *Scotica*, Dav.		x	x		
,, (?) *Thomsoni*, Dav.		x			
Discina nitida, Phill.	x	x	x	x	x
,, *Craigii*, Dav.		x	x		
Crania quadrata, M'Coy.		x	x		
CLISTENTERATA.—*King.*					
Dielasma (*Terebratula*) *hastata*, Sow.	x	x	x		
,, ,, *sacculus*, Mart.		x	x		
,, ,, *vesicularis*, De Kon.		x	x		
,, ,, *Gillingensis*, Dav.		x			
Spirifera duplicicosta, Phill.	x	x			
,, *triangularis* (?), Mart.			x		
,, *trigonalis*, Mart.	x	x	x		
,, ,, var. *bisulcata*, Sow.	x	x	x		
,, *triradialis*, Phill.		x			
Martinia (*Spirifera*) *glabra*, Mart.		x	x		
,, ,, *ovalis*, Phill.	x	x			
,, ,, *Urei*, Flem.	x	x	x		
,, ,, *Carlukensis*, Dav.		x	x		
Reticularia (*Spirifera*) *lineata*, Mart.	x	x	x		
Spiriferina cristata var. *octoplicata*, Sow.	x	x	x		
,, *insculpta*, Phill.			x		
,, *laminosa*, M'Coy.	x	x			
,, *Etheridgei*, Dav.		x			
Athyris ambigua, Sow.	x	x	x		
,, *plano-sulcata*, Phill.		x			
,, *Royssii*, Leveillé.	x	x	x		
,, *pisum*, Dav.		x			
Retzia radialis, Phill.	x	x	x		
Rhynchopora Youngii, Dav.		x	x		

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GENERA AND SPECIES.	Calciferous Sandstone Series.	Lower Carb. Limestone Series.	Upper Carb. Limestone Series.	Millstone Grit Series.	Coal Measures.
Camarophoria crumena, Mart.		x			
,, *globulina*, Phill.		x			
Rhynchonella pleurodon, Phill.	x	x	x		
,, *pugnus*, Mart.		x	x		
,, *Brockleyensis*, Dav.		x			
Orthis resupinata, Mart.	x	x	x	x	
,, *Michelini*, Leveillé.		x	x		
Streptorhynchus crenistria, Phill.	x	x	x	x	
,, ,, var. *radialis*, Phill.		x	x		
,, ,, var. *senilis*, Phill.			x		
,, ,, var. *cylindrica*, M'Coy.		x	x		
Strophomena rhomboidalis var. *analoga*, Phill.	x	x	x		
,, ,, var. *distorta*, Sow.			x		
Productus giganteus, Mart.	x	x	x		
,, *latissimus*, Sow.	x	x	x		
,, *cora*, D'Orb.	x	x	x		
,, *semireticulatus*, Mart.	x	x	x		
,, ,, var. *Martini*, Sow.	x	x	x		
,, ,, var. *concinnus*, Sow.	x	x			
,, ,, var. *Scoticus*, Sow.		x			
,, *costatus*, Sow.	x	x	x		
,, ,, var. *muricatus*, Phill.		x	x		
,, *scabriculus*, Mart.	x	x	x		x
,, *pustulosus* (?), Phill.		x			
,, *carbonarius*, De Kon.			x		
,, *longispinus*, Sow.	x	x	x		
,, *Griffithianus*, De Kon.		x			
,, *sinuatus*, De Kon.			x		
,, *fimbriatus*, Sow.		x			
,, *aculeatus*, Mart.	x	x	x		
,, *Youngianus*, Dav.	x	x	x		
,, *punctatus*, Mart.	x	x	x		
,, ,, var. *elegans*, M'Coy.		x	x		
,, *undatus*, Defr.		x	x		
,, *mesolobus*, Phill.		x			
,, *spinulosus*, Sow.		x			
,, *Deshayesianus* (?), De Kon.		x			
,, *complectens*, R. Ether., jun.		x			
Chonetes Laguessiana, De Kon.	x	x	x		
,, ,, var. *gibberula*, M'Coy.		x			
,, *Buchiana*, De Kon.		x	x		
,, *polita*, M'Coy.	x	x	x	.	
Aulacorhynchus Davidsoni, Barrois.		x			
Total number of species found in each series,	33	67	52	5	4

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No. XII.—The Old Red Sandstone of Lanarkshire, with Notes on Volcanic Action during Old Red and Carboniferous Times.

By John R. S. Hunter, D.Sc., LL.D., F.R.Ph.S.E., etc., *Honorary Member.*

[Read 28th May, 1885.]

The Old Red Sandstones or Devonian formation, mainly composed of nearly pure sandstones and conglomerates, and lying above the Upper Silurians, is largely developed in Lanarkshire. The lower beds of conglomerate extend over a considerable portion of the parish of Lesmahagow. The matrix of this conglomerate is a coarse-grained sandstone of a dun or purple colour, with quartzite nodules of a slightly flattened oval shape of from half an inch to 15 inches in diameter, and pieces of red and bluish-grey jasper. These beds are quite different from the higher conglomerates of the Old Red, which are light brick red in colour.

The Old Red is best developed in the Hagshaw, Whitehaugh, Greenock, Avon, Glengaril, Kype Water, Lesmahagow, and Lanark districts, and the Tinto and Carmichael districts from Tinto Hill to the Clyde, also in the Kilncadzow or Carluke area to the N.-E. of the town of Lanark. All these are connected with each other.

A good idea of the structure of Lanarkshire may be got by supposing a ridge or axis of rock to run through the middle of the field in a sinuous, easterly and westerly direction. From the north side of this ridge, the limestones, coals, etc., dip northwards, forming the Clyde coal-field. On the south, a small area of the Ayrshire coal-field is seen round Glenbuck. The ridge itself consists chiefly of Lower Old Red, forming an expansion of the belt of that formation which stretches across the country from near Edinburgh into Ayrshire. On the west side, it is prolonged northwestward by the Lower Carboniferous volcanic rocks running from Stonehaven as a broad strip of elevated ground between the plains of Ayrshire and the valley of the Clyde. Owing to numerous foldings and fractures of the Old Red Sandstone, portions of the underlying Upper Silurian strata are brought to the surface, but the former wraps round them, and abuts against the great Lower Silurian uplands of the South of Scotland. The strata of the Old

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Red attain a great development between the basin of the Clyde near Lanark and the Ayrshire coal-fields, reaching possibly a thickness of 12,000 to 15,000 feet. At Bonnington Falls, the rocks occur in layers of from an eighth of an inch to several feet in thickness, the former having clay nodules interspersed. From Bonnington to Cora Linn, the Clyde flows through a magnificent wild ravine of about half a mile in length, the waters of the Clyde being hemmed in by vertical jointed walls of Old Red strata, at Cora Linn the water descending a sheer fall of 84 feet, and a short way below the precipitous sides being about 150 feet high. The sandstone varies considerably in colour, sometimes resembling a hard ferruginous clay, while a large portion is thickly studded with plates of mica.

The lithological features at Stonebyres Falls are similar to those at Cora Linn, except that here and there we find a great cliff of conglomerate protruding into the stream from beneath the Old Red Sandstone. Thin seams of conglomerate are also interlaminated with the prevailing rock at various heights. The contained fragments are both rounded and angular, consisting of quartz, felstone, porphyry, claystone, greenstone, and jasper.

At Tinto the Old Red formation contains intercalated masses of trappean agglomerates, which, with interbedded felspathic rocks, extend north-eastwards towards the source of the Nith. In the valley of the Irvine Water at Lanfine, Ayrshire, it consists of a grey micaceous flagstone with trappean agglomerates and felspathic traps. Here it has yielded a few specimens of *Cephalaspis Lyellii*, being the only locality in the South of Scotland where remains of this fish have been found till very recently (1884). I have now the pleasure of showing you a magnificent specimen from the Lower Old Red of Lesmahagow, the portion represented being that of the buckler or shield-plate of the head. The position of the eyes is plainly visible, and from them two ridges extend backwards to the end of the shield-plate, but do not show any portion of the horn-like processes, which have probably been broken away. The most interesting point in connection with the specimen is the occurrence over the whole surface of the buckler-plate of a strongly marked system of vascular canals, which branch outwards in all directions from central stems, and which, as they reach the outward extremity bordering the rim, become very much branched. Where a portion of the buckler-plate has been lifted off on the

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left hand side, the inner surface shows a peculiar strongly lobed appearance. The vascular ornamentation of the Lesmahagow specimen is more apparent than that of either English or Forfarshire ones. On comparing the canals on my specimen with those seen on a portion of the shield of *Zenaspis Salweyi*, I find the former to be much larger than those figured, (and magnified 4 diam.) in the valuable monograph on the fishes of the Old Red Sandstone by Mr. James Powrie, F.G.S., Reswallie, near Forfar.*

Before the Lesmahagow specimen was sent to Mr. Powrie, my kind friend, Mr. John Young, F.G.S., of the Hunterian Museum, Glasgow, carefully examined it, and as we came to the conclusion that it probably was a new species, I have ventured to name it provisionally *Cephalaspis Glottensis*, but I hope that before long other examples may be found in the same horizon, so that the doubtful points may be fully cleared up.

Organic remains of marine origin were found by the officers of the Geological Survey at Carmichael Burn in a thin shale about 5,000 feet above the base of the Old Red; but the formation, so far as yet observed in Lanarkshire, is very unfossiliferous, indicating a condition of things in which the waters were not conducive to organic life, probably from the excess of iron sediments in them. Peroxide of iron is also unfavourable to the preservation of organic remains, and may, in many cases, account for their disappearance. Lately, when examining a few cut corals which had been imperfectly cleansed from this substance, which is used for polishing them, I found that the smooth surfaces had, in the course of a few hours, been largely bitten into.

* Mr. Powrie, after comparing this specimen, wrote me as follows:—"From a large portion of the head being broken off, and thus its form when entire being lost, and also no portion of the outer surface of the cephalic plate being preserved, it is impossible to say with anything like certainty to what species it may have belonged, but on the whole I think it more probably belongs to *Cephalaspis Lyellii* than to any other with which I am acquainted. It is the impression of the inner surface containing the vascular canals, and these are better preserved in your specimen than in any one of the many others I have examined. Indeed, from the preservation of these canals, and their so distinctly marked character distinguishing it from those with which I am acquainted, I think it just equally probable that its species may be distinct from any of our Forfarshire Cephalaspids." Since the publication of the valuable monograph by the Palæontographical Society, very little has been added to our knowledge of this interesting genus.

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The extremely red colour of the strata seems to indicate some peculiarity in the original medium of deposition by which it may have been communicated to the deposited sediments. What reason can be assigned for the various coloured sandstones we frequently meet with—red, white, yellow, and many different shades? Is it owing to the greater quantity of iron or other metallic oxides, or to some influence of electrical agencies by which rocks of all ages have been more or less affected?

A small space often separates, both horizontally and vertically, the white from the red-coloured sandstone, which favours the supposition that the elements of colour have been induced subsequent to the deposition of the rock. White circular spots are very common in this rock. In these it is evident that either the colour has never been present or has been afterwards expelled. It has often been supposed that such spots are due to the presence of organic matter, but as no traces of that have been found in them it is more reasonable to suppose that they are due to chemical causes.

One of the most remarkable features of the Old Red Sandstone in the West of Scotland is the occurrence of numerous basic trap dykes, probably of Tertiary age, with a general direction of west to east. The same dykes also traverse the coal strata of Ayrshire. Two areas of older volcanic action seem to have existed, one in the north-east, with its centre in the Pentland Hills area, where the porphyrites are thickest, the other in the south-west of Lanarkshire, while between them lay a space originally occupied by small islets of Upper Silurian rocks, over which the thick grits and conglomerates make their appearance. During the same geological period volcanic action was frequent along the whole of the midland valley of Scotland, since to that time we must refer the origin of the Ochil and Sidlaw Hills, part of eastern Berwickshire, and the long line of uplands from the Pentland Hills through Lanarkshire, across Nithsdale, and far into Ayrshire. Early in the Carboniferous period, and from then onwards through nearly the whole of the time occupied by the deposition of the Calciferous and Carboniferous limestone series, the district to the west of Edinburgh was dotted over with small cones, which were usually of tuff, but sometimes of different basic dolerites, more especially in the space between Bathgate and the Forth, where a long bank, chiefly formed of such lava flows, was piled up over and amongst the pools and shallows in which the

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limestones, sandstones, shales, and coals, were afterwards accumulated. Northwards, also, similar volcanic activity was shown in the Fife coal-tracts near the Forth, while eastwards between Haddington and Dunbar there lay a distinct volcanic centre or focus, from which great sheets of porphyrite were ejected so as to form a bank over which and around the Carboniferous limestone series was at length deposited.

An interesting feature is the series of doleritic dykes which show a marked uniformity of direction, generally westerly and easterly, and which, when they traverse tracts of trappean rocks, continue as readily separable from them as when they intersect sandstones or shales. These dykes run across a great part of Scotland and into the North of England.

Faults and dykes, as may be seen from the geological maps of the district under review, are numerous, both in the Old Red Sandstone and in the Carboniferous rocks. Dykes are fissures filled with foreign matter, generally of igneous origin, which cut the strata in a perpendicular or inclined position, and are frequently of great vertical extent, the strata having been in some instances tilted up, or in others depressed on one side or other of the dyke. They sometimes lie obliquely to flows in the plane of stratification. Faults have evidently been produced by earth movements and pressure from beneath, occasioned probably by the same subterranean forces which ejected the matter of the dykes, and of those interstratified and intrusive beds of igneous rock of such common occurrence in our coal-fields.

Intrusive sheets of diabasic rock or dolerite are frequently observed in some parts of the Old Red, but in other places they seem interbedded. A fine example of the former may be found in the great intrusive sheet which extends from the East Neuk of Fife westwards through the Lomond and Cleish Hills, appearing again in the Abbey Craig at Stirling, and continuing on to Kilsyth, but always near the horizon of the Main or Hurlet limestone. The changes produced on the surrounding strata by the trap have been in many places excessive, their structural characters being altogether altered. Coals and limestones are rendered valueless, while shales and sandstones are greatly indurated at the points of contact. Sandstones, shales, and limestones are often greatly jointed and fissured, and sometimes assume the external form of basalt, while the dolerite has become calcareous and felspathic.

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In the Wishaw coal-field, Glasgow Iron Co.'s No. 2 pit, there is a body of trap of a whitish colour, thirty feet from the bottom of the splint coal, about two feet thick and perpendicular in position, running due north and south, and probably being an altered dyke of dolerite. In Newmains district numerous dykes are observed, some being greenish and others whitish, which is due to various stages of alteration of the dolerite. In the parish of Carluke trap rocks, chiefly dolerites of various kinds, are seen at Hillhead, Barnhead, and Westerhouse. From Hillhead they run eastwards by Thorn and Bashaw. At Westerhouse they are merely seen projecting from a small elevation, and in Guildshields Burn they are seen passing towards Burnhouse. At Hillhead, where they are seen in beds 20 feet thick, and were at one time extensively worked for road metal, the columnar form is finely shown. The top and bottom is close grained and brittle, while the centre is highly crystalline. The wider fissures between the columns are filled with clay and boulders, while the smaller ones contain various crystals. The trap overlies clay shale, blackened in colour and otherwise altered. The dolerite terminates partly on the blue shale above the Hosie limestone, which is burnt of a brick colour. In some parts of its course it lies between the Hosie and the Main Post limestones. At Hillhead the Hosie limestone passes round the west point of it at a high angle, almost on edge, dipping on the north side to the north-west. At the west point of the dolerite the dip is west, on the south, south-west. At the extreme west point the ironstones are thrown back upon themselves, and the shale and its ironstone balls have a peculiar colour, while the limestone which lies on the dolerite is a soft mass of ochre. At Guildshields a volcanic rock is cut through by the stream. Near Kilncadzow several remarkable necks were exposed in the opencast ironstone workings. They cut the strata vertically and were circular in shape, being somewhat wider at the top of the quarry than at the bottom. They were filled with angular debris or agglomerate of Carboniferous rocks dipping towards the centre of the neck, where also the largest blocks of sandstone, shale, limestone, ironstone, etc., occurred. None of the fragments were igneous rock, but a few string-like veins of white dolerite penetrated the mass here and there. The white dolerite was seen at No. 2 pit, Old Hill, when sinking to the Raesgill ironstone, and was again observed at Langshaw when an air shaft was being put down to the main limestone workings.

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Again, in No. 3 Main Limestone pit at Braidwood Station the same character of trap was again seen, but the bed was horizontal and formed the roof of the main coal formerly wrought by the author's firm. The limestone here was in a very confused condition, showing that probably other dislocations were near at hand.

Craigenhill doleritic rock, which is of a black colour, was frequently got below the main limestone, running from two feet upwards in thickness. At Coldstream in the Old Red Sandstone a reddish felstone is seen, and with a thickness of 30 feet is extensively worked for road metal. At No. 2 Orchard Gas Coal pit, near Crossford, a vein of dolerite runs from north-east to south-west. It penetrates up the shaft, so far as is seen, 27 fathoms, and its width is between two and three feet. In the dross coal above the gas coal the burning by the trap extends about three feet, while the gas coal is only altered for about one foot. The sandstone has also become very like kinglestone, and the fireclay is black and vitrified.

In the parish of Lesmahagow many of the hills are of igneous felspathic rock, intermixed with Old Red Sandstone, the most conspicuous being Todlaw in the upper and Blackhill in the lower end of the parish. Both of these hills consist of great outbursts of felstone porphyry, but, while the first is dark in colour the other is light. The Clarkstone, Dillar, and Boreland Hills, and Differick, which are composed of Old Red Sandstone, all lie in the lower end of the parish and slope towards the Clyde, whilst the Lowries, Gregstone, Wardlaw, Whiteside, Auchrobert, Skillyhill, and Chapel Hills, situated in the upper division, show eruptive action. At Cumberhead and Pockmuir Burn the white concretionary or nodular limestone appears, and, like the other rocks, in a vertical position. The Old Red rocks extend to the south and form Blackend Hill. In the burn beyond Craigenrigg, they again appear in conjunction with the concretionary limestone, expanding towards the south and forming the great masses of the Hagshaw Hills, which are only interrupted by hornblende, porphyry dykes, and small patches of Silurian rocks. At the other side of the parish they cross Kype Water and form Kyperigg and the surrounding moorland districts, with a few patches of igneous rocks. From the Kerse onwards by Auchenheath Cottage and Craignethan Castle to the Clyde at Evonford, rocks belonging to the Carboniferous formation are exposed, but have been greatly broken up by dislocations. Near Lochanbank Mill on the Nethan the strata have been upheaved to

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the north at least 80 fathoms, so that instead of finding corresponding beds upon opposite sides of the dislocation, we must look for them on the north side about 450 feet higher up in the section. The upheaving force has evidently come from the east, probably proceeding from the felstone porphyritic beds found in the Old Red Sandstone on the Clyde near the village of Hazlebank.

Another great dislocation is found between Cora Mill and Craignethan Castle, and here the strata are upheaved to the north more than 100 fathoms, the disturbing element, which has here come from the east, raising up the rocks underlying the farms of Blair, Craignethan, etc., whilst upon the Auchenheath side the outcrop only has been affected, the coal beds at their outcrop on Hallhill Burn being nearly on edge, as if the result of pressure from Stonebyres Hill.

Numerous dykes or dislocations have recently been observed during the working of the Auchenheath gas coal, some being of great magnitude, and others very small. One of the smaller ones commences at a thickness of about four or five inches, and running to the north-west gradually increases to six feet and upwards.

Slickensides are often seen in perfection near these alterations of strata, showing fine groovings and markings, whilst in other places some of the strata are polished like a mirror. The fireclays are ribbed, and some of the shale is cut through as cleanly as if by a knife, with the faces as bright as glass.

Near Auchenheath the intrusive dolerite rock is from three to nine feet thick above the gas coal, which it often penetrates. It is seen at Langlee above the coal, while in No. 15 pit it is beneath it. In this last pit it extends up the shaft as far as the position of the second Carluke coal, and is again seen at Craignethan Crags.

The ironstone below the gas coal at No. 15 pit is in one locality completely charred, while the coal is rendered useless. The colour of the dolerite here is light grey, which changes to nearly white when near the coal, with here and there black patches. From these facts it is evident that volcanic action has been not only very frequent amongst the Lanarkshire rocks, but has extended over very different periods of time.

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No. XIII.—Notes on the Discovery of a Fossil Scorpion (*Palæophonus Caledonicus*) in the Silurian Strata of Logan Water. By John R. S. Hunter, D.Sc., LL.D., F.R.Ph.S.E., etc., *Honorary Member.*

[Read 28th May, 1885.]

[Summary.]

In two previous papers read to the Society * I referred to the results of former expeditions to the Logan Water district in the Lesmahagow hills, and I then described the geological features of this group of fossiliferous Silurian strata, known to all who are interested in Scottish palæontology.

In June, 1883, I started on another expedition to Logan Water, under canvas, and for the first few days experienced weather wet and stormy enough to try the patience of the oldest campaigner. Nor were the rocks more favourable to us than the elements, and our earliest explorations were absolutely barren of results. But patience and perseverance conquer many difficulties, so after a visit home to procure dry clothing, we set to work with renewed vigour to open up a new horizon. Here a splendid specimen of an organism which appeared to be entirely new to me was turned out. Its curious comb-like structure suggested strongly to my mind the fact that it bore a great and general resemblance to a recent Scorpion. Soon after plant remains were discovered on the same horizon, and the probability became all the stronger that here we had disentombed a land-inhabiting and air-breathing animal from a lower position in the earth's crust than any previously known to us. If this supposition proved correct, here was a find surpassing any of my former discoveries in the Logan Water Silurians, and rendering the hardships we had undergone as nothing in comparison.

Later in the year, when I had leisure to examine the specimens collected during this expedition to Logan Water, I showed the organism above mentioned to several of the members of the Geological Society of Glasgow, amongst others to Messrs. John Young, F.G.S., and David Forsyth, M.A. After careful examination both of these gentlemen corroborated my first impressions as to the stranger being a true Scorpion. Though in a manner

* *Transactions*, vol. vii., p. 56, and p. 272.

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recognizing the importance of the discovery, I took no further steps to have the fact recorded until the 18th of December, 1884, when after reading, before the Edinburgh Geological Society, a paper sent me by Prof. Gustave Lindström of Stockholm, entitled "Preliminary Notice on a Silurian Scorpion—*Palæophonus nuncius*, Thorell and Lindström—from the Isle of Gothland," I then exhibited the Logan Water specimen and read notes on its occurrence. Writing afterwards to Dr. Lindström, I mentioned the facts of the case, and he was generous enough to waive his right to priority of discovery.

This example of *Palæophonus Caledonicus* is as nearly perfect as any fossil organism in such old rocks is almost ever found. It is, however, fractured across, but this is rather an advantage, as it allows us to get a glimpse of structure which would have been otherwise hidden. A portion of the tail is turned sideways. The whole of the animal is unusually well preserved as compared with other Scottish Carboniferous specimens, which besides being squeezed flat, have some of the more perishable organs decomposed. Dr. John Young, Professor of Natural History in the University of Glasgow, has kindly consented to figure and describe this specimen, and I therefore hope to bring before you the result of his observations on a future occasion.

The vertical range of fossil Scorpions in Scotland may now be stated to extend upwards from the Upper Silurian to the Carboniferous formation. Their remains are frequently found in the Calciferous sandstones of the South of Scotland, where they are represented by the genus *Eoscorpius*. During Carboniferous times these air-breathers seem to have lived in abundance, as the strata of Fife and the Lothians are found to contain numerous fragments of their bodies. In the former county they have been traced by Mr. W. Tait Kinnear, an ardent worker of the Edinburgh Geological Society, extending from the Calciferous sandstones of Burntisland to the highest strata of the coal measures in the Leven and Largo districts, besides in other localities.

Is it not somewhat strange that so few remains of Scorpions have been found in the West of Scotland? a single fragment from the Carboniferous rocks only having been found in the Carluke area. It is high time that the West country geologists made a thorough search for traces of those interesting creatures, as no reasonable doubts exist that they will be found if carefully looked for.

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No. XIV.—Notice of the late Mr. Andrew Patton, East Kilbride, *Corresponding Member*. By James Coutts.*

[Read 15th October, 1885.]

It will not, I am sure, be thought out of place that I should take upon myself the melancholy duty to-night of bringing before the Society as a body, what many of the members individually are already aware of, that our esteemed friend and Corresponding Member, Mr. Andrew Patton, of East Kilbride, departed this life on the 23rd of July last.

Many of the interesting and in some cases unique specimens of fossils from Mr. Patton's collection have been so frequently brought before the Society's meetings of late years that his name has become almost a household word amongst us, and I am certain that there is no one of us who will not regret his comparatively sudden and unexpected death.

Our friend was born of humble parentage in the county of Northumberland, near famous Flodden Field, in the year 1821; and, as might have been expected, he was sent at an early age to work in the colliery where his father was employed. His chances of schooling were thus very limited; but he soon began a system of self-culture which grew with his growth, and continued literally to the end of his life.

Entering into the bonds of matrimony as a young man, Mr. Patton came to Scotland, and obtained work at several collieries in Ayrshire and Renfrewshire, settling down eventually about the year 1858 as manager of the Calderwood Cement Works, in East Kilbride, and this situation he held for nearly a quarter of a century, until, indeed, the failure of Messrs. John Brown & Co., the lessees of the workings, which were then closed.

Having not only a practical but a theoretical experience of mining operations, Mr. Patton was soon found by both masters and men to be a thoroughly reliable and competent manager, while his calmness and self-possession in times of emergency or danger were of infinite service in keeping the works free from accidents. Indeed, his reputation extended so widely that he received various

* The author of this paper was himself removed by death a few months later. For a short notice of Mr. Coutts see *postea*, page 177.

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tempting offers from coal and iron masters to change employment, but his affection for East Kilbride, where his early married life had been spent, and in the churchyard of which more than one of his children had been laid to rest, prevented him from accepting any of them, however advantageous they seemed to be from a worldly point of view.

Many years ago Mr. Patton began to interest himself in the fossil remains found in the strata amongst which much of his time was passed, and he soon became an ardent and skilful collector. By degrees the richness of his collection became known to palæontologists, and frequent visitors began to find their way to East Kilbride. To these he was only too liberal in the bestowal of specimens, and few left his house without some tangible memento of their visit. Specimens of the rarer and undescribed forms were coveted by the authorities of the public museums, and were on different occasions acquired by the Museum of Science and Art in Edinburgh, by the British Museum, and by others.* From first to last, the number of species added to the lists by Mr. Patton's instrumentality must have been considerable, while some of his discoveries still remain undescribed. One of the most notable of his finds was the fine specimen of *Psephodus magnus*, Ag., which has been lately figured and described by Dr. R. H. Traquair, of the Edinburgh Science and Art Museum, in the last part of our *Transactions*. (See vol. vii., pt. 2, page 392.)

In 1876, Mr. Patton sent to Glasgow for exhibition at the Corporation Galleries during the Meeting of the British Association a small but extremely interesting case of fossils from the cement limestones, and which attracted a considerable amount of attention. It was afterwards sent on loan to the Greenock Museum, where it remained till a quite recent date.

In 1880, he was, as a mark of respect, elected a Corresponding Member of this Society, an honour upon which he placed high value, and in the session of 1883-84 he contributed an interesting paper upon the Geology of his district, accompanied by sections drawn to scale, which showed his ability as a self-taught artist. To this paper I had the pleasure of appending a list of the fossils found in the East Kilbride district, the details being, of

* It may interest members to know that Mr. Patton's collection of East Kilbride fossils has lately been acquired by our Honorary Member, Dr. Hunter, for the "Braidwood collection," which he is now forming.—ED.

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course, to a considerable extent supplied by Mr. Patton himself. (See vol. vii., pt. 2, page 309.) The *Phyllopoda* in the list appended to Mr. Patton's paper were described by Mr. Etheridge, jun., and Mr. Woodward, in the *Geological Magazine* for 1872-73; *Palæsquilla Pattoni*, by Mr. Peach; and *Fissodus Pattoni*, by Mr. Etheridge, jun.

In addition to his ordinary work and his scientific pursuits, Mr. Patton took a great interest in matters relating to the social well-being of the district, the great success of the local Co-operative Society being due largely to the assistance he afforded it in its early days. He was above all of a most kind-hearted and simple-minded disposition, but so retiring and unobtrusive in all his actions that of him it might truly have been said in the words of Goldsmith, "He did good by stealth, and blushed to find it fame."

In conclusion, I may be permitted to state that though my acquaintance with Mr. Patton only began in the year following the Glasgow Meeting of the British Association, it quickly ripened into friendship, and consequently I formed the medium through whom so many of his rarer specimens were brought under the notice of the members. Mr. Patton has left to mourn his loss a wife and family, and I would, in conclusion, suggest that a motion of condolence with them in their loss be passed to-night, and an extract from the minutes be sent by the Secretary to Mrs. Patton.

No. XV.—The Geology of the Territory of Idaho, U.S., and the Silver Lode of Atlanta. By James Thomson, F.G.S.

[Read 11th December, 1884.]

[Summary.]

The Territory of Idaho is situated on the north-west extremity of the United States of America. It is bounded on the south by Utah, on the west by Oregon, on the north-west by Washington, on the north by British Columbia, on the east by Montana, and on the south-east by Wyoming. Its geological phenomena are varied and interesting. Immediately after crossing the boundary between Idaho and Utah there is an extensive sheet of vesicular lava, which extends for 340 miles across the territory in rolling undulations

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which resemble Atlantic waves. The long axes of these ridges trend from south to north, and are here and there broken by circular depressions which prove on examination to be the mouths of extinct volcanic craters. Around their margins the lava is covered by a thin vitrified crust with minute undulations, like the ripple marks on a sandy shore, which are deflected in every direction, indicating that the flow of lava had been in some way obstructed.

The Snake River, resembling with all its turnings and windings the coils of an enormous serpent, has cut a deep channel, and its escarpments present an unbroken face of vesicular lava. Near the surface the vesicles are minute—in this respect like recent pumice-stone—but become larger and more irregular as we descend in the sections. Near the middle of this dreary waste, turning to the east at Mountain Home, the rough pathway lies across the surface of the lava for fully 30 miles. About midway the party crossed a series of mountains, trending south by west, the volcanic rocks being vesicular and rudely columnar, the columns variable, and usually from ten to twelve feet in diameter. Further to the east a descent was made into a plain, which seemed to be a vast extinct crater, with numerous miniature craters scattered throughout the main depression. On the northern margin the igneous rocks become more and more compact, merging into felspathic porphyry, which ultimately as dykes is seen piercing the granitic ranges of the neighbouring portion of the Rocky Mountains.

At the junction the party descended for about 3,000 feet into Lime Creek Valley, through which the South Bosie River flows, the pathway being along its banks. In the bed of the river were found boulders, representing the petrological history of the surrounding country—porphyries varying from compact cream-coloured varieties to deep greyish-blue ones, and running into vesicular dolerite, besides the different kinds of granite of which the mountains of the district are composed. On emerging from this valley one of the deep "gulches" or ravines which intersect the mountains in every direction was entered. On either side the slopes are all but precipitous, rising from 3,000 to 5,000 feet overhead, and covered with gigantic pines of from 200 to 300 feet in height, which grow up to 9,000 feet above sea-level. The rocks are granitic, and are traversed in all directions by quartz veins, cut and pierced in places by the porphyry formerly spoken of. The path for about 15 miles ran over mountains and through forests

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and deep "gulches" of the most varied character. At one part we were in the depths of the forest, while at the next opening we looked down into a "gulch" several thousand feet deep, while beyond the intervening depression we saw the perpetually snow-clad peaks rising from 10,000 to 12,000 feet above sea-level.

Such is the track until Rocky Bar, our destination for the night, was reached. In this part of the world there is no twilight—the sun sets, and we were all but instantly enshrouded in the deepest darkness. Having travelled so far across the lava plains, over the mountains, down into and along the margins of numerous "gulches," and through deep forests, there was no reluctance to end the day's work.

In the grey dawn of the next morning, at half-past five o'clock, the party were again on the road, taking first through the "city," which consists of a few scattered and irregularly built wooden shanties, placed on both sides of a deep "gulch," which is bounded by mountains 3,000 to 4,000 feet high. After an eight-mile journey through country similar to that previously crossed, the path began to ascend the Hogsback Mountain, which is clothed with tall pines up to the 9,000 feet level, and on reaching the summit the scenic aspect was found to be fine beyond description. On the north are first seen the Sawtooth Mountains; on the east we look up to Prospect Peak, from 10,000 to 11,000 feet high; on the west is a "gulch" about 4,000 feet below, with various lateral "gulches." Beyond the nearer mountains are seen the peaks of the snow-clad Blue Mountains. If all this outlook is varied in its physical aspect, no less so is its accompanying vegetation, from the great pines on the mountain slopes to the trembling aspens clothed in their rich autumnal tints, ranging from deep bluish-green to numerous shades of pale green, yellow, and even deep gold colour, whilst amongst other members of the vegetable world there are many other varieties of tint, from pale brown to blood-red. Above, below, near and far, all is clothed in nature's own wild and beautiful colouring.

Once more we proceed down the edge of a "gulch," near the bottom, the way in the distance seeming to be closed by a barrier extending across it, and ascending far up the sides. It is a gigantic dyke of felspathic porphyry, serrated and pinnacled along the top. The descent is steep until we reach the dyke, when we turn sharply round, and on looking up from the other side we

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realize its magnitude and appreciate its great height. It pierces the mountain side, and is exposed to view for fully 1,000 feet upwards. The banks of the Middle Bosie River are now reached, and here, as in many of the "gulches" already passed, Chinamen were industriously at work at what is termed "placer" gold digging, which is simply washing the sandy and gravelly detritus brought down from the higher levels by natural causes. These Chinamen earn, it is said, from two to twenty dollars a day, even in spots that have already been washed by men of other nationalities. An examination of the wash-dirt led to the conclusion that the whole region here is more or less impregnated with gold.

The party at last reached its destination—Atlanta city—situated on the west side of Atlanta Mountain, and on the east side of the Middle Bosie River. It is surrounded by the Sawtooth range of mountains, the name of which was suggested by the presence of numerous bosses and dykes of felspathic porphyry ejected through the grey granite, of which these mountains are composed. The later igneous rock, where it came into contact with the granite, has altered it and rendered it more or less friable, and becoming disintegrated by weather and other abrading influences, it has been afterwards washed down to the valleys by melting snow and by rain, leaving the igneous rocks projecting in pinnacled masses, serrated on their upper edges.

Atlanta Mountain stands isolated from all other eminences, and reaches a height of fully 1,600 feet above the surface of the central depression from which it rises, its altitude above sea-level being from 7,000 to 8,000 feet. It occupies an area of about four square miles, the Middle Bosie River which flows on its north and the Yuba River on its south side forming a junction at its western extremity. It is formed, like the surrounding mountains, of a grey granite, containing large crystals of felspar. Along the summit there is a large fissure, extending from the eastern to the western side, which has been produced by the local disturbance caused by the eruption of the igneous rocks formerly referred to. This fissure was originally fully 50 feet broad, and has subsequently been more or less filled up with decomposed granite and quartz, containing a variable percentage of both gold and silver, and termed in the district "low grade ore." This is pierced in various directions by lodes of silver ore, more or less intermixed with gold. Along the lateral margins of the central lode of high grade ore

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there are numerous lateral fissures of various dimensions, which also contain the precious metals. The fissures near the eastern extremity converge inwards in a slanting direction towards the central area of the great central fissure vein; while those on the western side also converge inwards to the centre from the opposite direction, indicating that the centre of the main fissure is the focus or principal body of the precious ore. The great main fissure extends from the Buffalo Mine on the east to the west for 8,000 feet, and gold and silver are present throughout the entire distance. In a tunnel cut on the bank of the Yuba River to the south of Atlanta Mountain, the precious ores were found at a depth of 1,600 feet beneath the surface.

It will thus be seen that here there is a continuous lode rich in the precious metals 8,000 feet in length and 1,600 feet in depth, and where proved by the Yuba tunnel 70 feet broad. If the lode is as broad throughout its entire length, an important problem is suggested as to how such a fissure became charged with the precious metals.

No. XVI.—A Short Notice of the Late Mr. James Coutts.

By John Young, F.G.S., *V.P.*

[Read 15th April, 1886.]

I am sorry to have again to bring before the Society this session another loss it has sustained by the death of our respected friend Mr. Coutts, which took place on the 19th March last, in the 76th year of his age. He was a member of the Society for the last eleven years, but was long previously known to many of us who were also members of the Natural History Society, of which he had been a member for nearly 20 years. Although his studies in natural science were taken up only after he had considerably passed the prime of life, yet he showed an enthusiasm in pursuit of them that was worthy of a younger frame. During all his membership he was a most regular attender of the meetings and excursions, and his familiar form will on these occasions be missed by all his friends.

Mr. Coutts attended my Class of Geology in the Mechanics' Institution for nearly ten sessions, and at the age of 66 or 67 he presented himself at the Government Science and Art Examina-

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tions, gaining from the Department a 2nd class certificate for geology, an honour which he was deservedly proud of.

He wrote several short papers on geological subjects, which were printed in our *Transactions*, or in the *Proceedings* of the Natural History Society, and was a constant exhibitor at our meetings of a great variety of specimens, invariably accompanied by a note of remarks which he had worked up in the most painstaking manner. During the last few years, as will be remembered, he, meeting after meeting, brought under the notice of members many of the choicer and rarer fossils from the collection of his friend, Mr. Andrew Patton, of East Kilbride, and only last year he spent a great amount of time and trouble in the preparation for the *Transactions* of a list of Carboniferous fossils found in East Kilbride, which was appended to Mr. Patton's paper on the Geology of that district. [See vol. vii., pt. 2, p. 324.]

Mr. Coutts' last appearance before the Society was at the opening meeting of this session, when he read a short notice of the life and work of his recently deceased friend and our esteemed corresponding member. [See page 171.]

Although it had been noticed by his friends that during the past year Mr. Coutts' health and strength had considerably failed, yet as he stood here that evening testifying to the worth of his departed friend, there was no one amongst us whose mind was crossed by the thought that Mr. Coutts himself was so shortly to be called away, and before the close of the same session. It is pleasing to us to know that his interest in all matters geological continued to the last, and that so long as he was able he beguiled his leisure hours by naming and arranging his small geological cabinet, which was almost entirely the fruits of his own collecting.*

In conclusion, I have to ask you to pass a vote of condolence with Mr. Coutts' widow and family, with an expression of our regret at the loss they have sustained, and also that our Secretary should send an extract from the minutes to Mrs. Coutts.

* Since the date at which this paper was read, Mr. Coutts' cabinet has passed into the possession of the Museum of Science and Art, Edinburgh.

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No. XVII.—Notes on some of the Principal Geological Papers at the British Association Meeting, Aberdeen, 1885.

By James B. Murdoch, F.R.Ph.S.E., *Hon. Sec.*

[Read 14th January, 1886.]

[Summary.]

After giving a short account of the more important papers submitted to Section C. (Geology), Mr. Murdoch referred to those bearing on two subjects which were of more than usual interest, viz., the age of the Elgin Sandstones and the succession of the North-West Highland Rocks.

The papers which introduced the former subject were—"The Elgin Sandstones," by Mr. J. G. Phillips, keeper of the Elgin Museum; and "On a new Reptile from New Spynie," by Dr. R. H. Traquair, F.R.S.E., Museum of Science and Art, Edinburgh.

Curiously enough, these Yellow Elgin Sandstones had been a subject of great contention at the previous meeting in Aberdeen—that of 1859—and now their age, which had been thought to be then finally settled, again came up for discussion at the meeting of 1885.

Up till 1852 there had been no question that these rocks were of undoubted Old Red Sandstone age, but in that year Mr. Patrick Duff of Elgin discovered in them the remains of a lizard (*Telerpeton*), while in 1859 Prof. Huxley found in the collection of the Rev. Dr. Gordon of Birnie, from the same strata, crocodilian remains (*Stagonolepis*) and those of another lizard (*Hyperodapedon*); and at the recent meeting Dr. Traquair reported the discovery of another form of lizard (which he named provisionally *Dicynodon*). The discovery of these reptilians, all of Triassic age, was supposed to finally settle the question, and the Elgin sandstones were therefore classed as belonging to the New Red formation, when lately in the same horizon, that of Cutties Hill Quarry near Elgin, Dr. Gordon of Birnie found fish remains (*Holoptychius*) almost in juxtaposition with those of the lizards.

Prof. Judd, in his presidential address, after referring to these finds and the previous state of the controversy, said that "the yellow sandstones, with reptilian remains, clearly overlie the undoubted Upper Old Red, and are separated from it by a well-marked bed of conglomerate. In other quarries in the district the manner in

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which these two series of strata have been thrown side by side by the action of great faults is very clearly exhibited." And again—"By a complicated series of parallel faults, the Devonian and Triassic Sandstones, which happen to have a general resemblance in their mineral characters, are found again and again thrown side by side with one another in the Elgin district, so that the error into which geologists fell before the discovery of the distinctive fossils of the two sets of rocks was a very pardonable one."

You will see from this that in Prof. Judd's opinion there was no loophole nor room for doubt; but not so thought Mr. Phillips, curator of the Elgin Museum, who read a long paper on the whole question as seen from a very different standpoint. He expressed his strong conviction, based upon a long and constant acquaintance with the strata worked at Cutties Hill, that there was no unconformability in the sections of the strata exposed, and that therefore it still remained to be proved, to say the least, that the upper or reptilian-bearing beds were not Upper Old Red. He admitted that the palæontological evidence was to some extent against this view, but then it was merely negative, while the stratigraphical evidence was, he asserted, quite in favour of it. He therefore urged strongly that the question should not be considered as decided till further evidence was searched for, and, if possible, obtained.

The subsequent discussion on these papers excited great interest in section C, and the President of course upheld the views generally expressed in his address. He said that though he agreed with Mr. Phillips' presentation of facts, he utterly dissented from his deductions. "It was altogether outside the experience of palæontologists to find reptiles in Old Red Sandstone. They might as well expect to find heather growing between tide-marks, or lilies on the tops of mountain ranges." Here there were found no less than four orders of reptiles, all peculiar to the Triassic period, while no reptile, with one exception (and that a doubtful one), had ever been discovered so low even as the Carboniferous rocks. It would require the strongest evidence to make him believe such would ever be found in Old Red Sandstone; and he might add that, for his own part, he would "require to see a *Holoptychius* in the mouth of a reptile" before he could be convinced.

One of the concluding excursions of the meeting was taken to Elgin, and as my homeward route lay in that direction, I formed

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one of the party, which, though a very large one, was most nobly entertained by the authorities and principal residents of the district. One detachment was taken to visit Cutties Hill Quarry, where a fresh trench had been cut below the present floor of the workings to the point of junction of the two disputed beds. The trench was unsatisfactorily narrow, but, so far as could be seen, though the two beds were unconformable, the points of mineral difference were apparently very small. Prof. Judd, Prof. Bonney, and other geologists of note, were to have a more exhaustive inspection on the following day, accompanied by Mr. Phillips and Dr. Gordon, of Birnie; but it is not within my knowledge whether they satisfactorily adjusted their differences of opinion or not.

The papers on the Highland Rocks were "The Great Highland Controversy: its Causes, Course, and Consequences," by Prof. C. Lapworth; "The Geology of Durness and Eriboll, with special reference to the Highland Controversy," by Messrs. B. N. Peach and John Horne, of the Geological Survey; and, though more indirectly, "Some examples of Pressure Fluxion, in Pennsylvania, U.S.," by Prof. H. Carvell Lewis; and "Notes on some Traverses of the Crystalline Districts of the Central Alps," by Prof. T. G. Bonney.

Before referring directly to the papers of Prof. Lapworth and Messrs. Peach and Horne, it will be well to give you a short summary of the main question at issue.

About the year 1820 Dr. John Macculloch, "that distinguished pioneer in Scottish geology," as Prof. Judd characterized him, asserted that in the Western Highlands there was a great formation of Red Sandstones and quartzites, both showing traces of sedimentary origin, and that associated with them were beds of limestone, with occasional fossils. He further said that this formation was far older than the Old Red, and gave it the name of the *Primary Red Sandstone.* He also showed that these rocks were often found resting unconformably upon the gneissose and schistose rocks of the Highlands, while elsewhere they were found to be overlain by, or to alternate with, crystalline schists and gneisses. He also found organic remains in the quartzites of this Primary Red Sandstone, and identified some of them as the tubes of marine worms, and others as *Orthoceratites.*

Murchison and Sedgwick next visited the district in 1827, and,

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objecting to Macculloch's definition and classification, maintained that his Primary Red Sandstone was merely an outlying portion of the true Old Red Sandstone.

In 1839 R. J. H. Cunningham published a geological essay on Sutherlandshire, in which he strongly supported Macculloch's views, and even brought forward some additional evidence in its favour bearing upon points of detail.

In 1854 Charles Peach discovered, in the debated formation, fossils which afforded undoubted evidence that they belonged to an early Palæozoic age.

In 1855, at the Meeting of the British Association in Glasgow, Sir Roderick Murchison admitted that the limestone of Durness, in which Mr. Peach had found his fossils, was of Silurian age, but at the same time defended his old views that the red sandstones were true Old Red; and in this he was supported by Prof. Sedgwick and other geologists.

In 1856 James Nicol, who, in his "Geology of Scotland," published in 1844, suggested the probability of the Highland schists and gneisses being simply altered shales and greywackes, revisited the debatable ground, and was able, as the result of his investigations, to confirm completely the conclusions of Macculloch and Cunningham, that the red sandstone belonged to an older formation underlying the quartzite and limestone. But he divided it into two—the lower, the Torridon Sandstone, lying unconformably on the gneisses, and the upper, consisting of quartzite, and limestone with fossils, resting unconformably upon and overlapping the sandstones.

Nicol continued his investigations during 1857-8-9, and in the latter year, at the Meeting of the British Association in Aberdeen, he finally enunciated his views concerning the question in dispute, and which may be summarized as follows:—

(1) He maintained that there exists in the N.-W. Highlands an enormously thick series of red sandstones, quartzites, and limestones, which rest unconformably upon the old gneisses and schists, and are much older than the Old Red Sandstone.

(2) That the repeating beds of quartzite and limestone are due to faulting and overthrow, and that Murchison's upper quartzites and limestones have thus no existence.

(3) That the supposed conformable upward succession of an older Palæozoic formation into overlying schist and gneiss is due

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to the thrusting of the crystalline rocks over the sedimentary ones by great overthrow faults; and

(4) That the relations between these crystalline and sedimentary strata were precisely similar to those constantly produced by lateral pressure in all great mountain chains, and consist of sharp foldings, inversion and faulting, on the very grandest scale.

These views of Nicol's were not generally accepted till long after this date, such observers as Harkness, Ramsay, A. Geikie, and Hull, throwing their weight into the opposite scale. Gradually, however, and principally within the last seven or eight years, fresh investigations have been made by Hicks, Judd, Bonney, and lastly by Prof. Lapworth and Messrs. Peach and Horne. These have one and all corroborated in the strongest manner the conclusions come to by Nicol, and the veteran geologist's views, which he never doubted would ultimately prevail, are now accepted by the geological world. In justice to Dr. Arch. Geikie, it should not be forgotten that he has had lately the manliness and courage to come forward and make a full recantation and retractation of his former views.*

Prof. Lapworth in his paper spoke of the discoveries of Heim and Lehmann on the Continent, and of their bearings on the question at issue with regard to the geological structure of Durness and Eriboll, which was due largely to vast mechanical changes such as up to this time we had no idea of. "The old stratigraphical rules of research begin to fail us here; we have to start from a new and totally different standpoint. In the sedimentary world superficial agents bring about the eternal flux of change and modification; in this new metamorphic world the agents of change are subterraneous. In the sedimentary world water is king. This newly-discovered world is ruled by a despot —the irresistible crush-creep lateral pressure, of whom we know absolutely nothing."

Messrs. Peach and Horne's paper gave an outline of the districts of Durness and Eriboll, and spoke of the existence of a series of reversed faults, which culminate in a great dislocation, bringing up the Archæan gneiss. Reference was made to the effect of this mass of gneiss on the underlying Silurian rocks. It was stated that the foliation of the eastern schists is the result of vast mechanical movements which took place after the Lower

* *Nature*, November 13, 1884.

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Silurian time, and that the crystalline character which the Archæan, Cambrian, and Silurian strata possess to the east of the great thrust-planes is due to shearing and re-crystallization. Applying the knowledge thus gained from the study of the eastern schists to the undisturbed Archæan masses, they had found in them evidences of similar mechanical movements. From a consideration of the phenomena they had observed, the authors concluded that regional metamorphism may take place in different geological periods, and that the origin of foliation in areas was that they had been subjected to regional metamorphism or mechanical movement which long afterwards had produced molecular changes in crystalline and plastic rocks.

The subject of the metamorphism of rock masses is one which is slowly but surely taking a prominent place in the consideration of petrology, and it can hardly fail to have an important bearing on the whole question as to the long-obscured origin of our older Highland rocks.

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PROCEEDINGS FOR SESSION 1884-85.

(27TH SESSION.)

SOCIETY'S ROOMS, 207 BATH STREET.

16TH OCTOBER, 1884.

Mr. JOHN YOUNG, F.G.S., *Vice-President*, in the Chair.

The CHAIRMAN, in opening the meeting, congratulated the members present that they were assembled to inaugurate the work of the 27th session, and expressed the hope that as the Society had prospered in the past so it would continue to do in the future. Touching on various recent aspects of geological science, he spoke more particularly of the much greater attention given to microscopic and chemical examinations of rocks and fossils, and urged upon all members the necessity of looking at even well-known forms under the new light thrown upon them by modern research.

Mr. JAMES COUTTS exhibited a specimen of *Fissodus Pattoni*, Etheridge, jun., a Fish Tooth from the lower limestone series of East Kilbride; also a specimen of *Ceratiocaris Pattoni*, Peach, a crustacean previously exhibited at a meeting of the Society, but then wrongly named *Palæocaris*, sp. [See *Transactions*, vol. vi., pt. 2, p. 304.] Both specimens were named after Mr. Andrew Patton, *Cor. Member*, East Kilbride, and were from his collection.

Mr. GEORGE R. ALEXANDER exhibited a symmetrically globular nodule found in sandstone near Bothwell, and evidently the result of chemical segregation.

Mr. JAMES WHITE read a paper entitled "A Glimpse of Skye, with Remarks on Volcanic Action" [see p. 105], which was illustrated by specimens of rocks from the district. At its close remarks were made by the Chairman, Mr. William Jolly, F.G.S., and others.

The CHAIRMAN (Mr. Young) then read a paper by himself and Mr. D. C. GLEN, F.G.S., entitled "Note on the Cathkin 'Osmund Stone' (a Volcanic Tuff)" [see p. 133], exhibiting different varieties of the mineral, of which sections were placed under the Society's microscope.

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SOCIETY'S ROOMS, 207 BATH STREET.

ANNUAL GENERAL BUSINESS MEETING.

13TH NOVEMBER, 1884.

Mr. DAVID FORSYTH, M.A., B.Sc., *Vice-President*, in the Chair.

The HON. SECRETARY (Mr. Murdoch) read the Report of the Council for the past year as follows :—

THE REPORT OF THE COUNCIL FOR SESSION 1883-84.

In accordance with the custom of previous years the Council beg to lay before the members their Annual Report on the business of the preceding session, the 26th in the Society's history. During the year the work has not been characterized by any events of special importance, but has moved on in a calm, satisfactory manner.

The MEMBERSHIP continues at about the average of late years, the number on the roll at the end of the session being—Ordinary members, 200; honorary members, 13; honorary associates, 8; corresponding members, 20; or a total of 241. The vacancies arising from various causes have been perhaps rather in excess of previous years, and the Council hope that members will see their way to enlist many of their friends—a promise of which is well shown by the billet of this evening, where no less than six new members are entered for election. One life member was elected during the year, but this is a source from which additional strength might be largely taken.

Of the MEETINGS of the Society, nine were held between October, 1883, and May, 1884, the attendance of members being always fair, but by no means so large as the interest of the material brought forward sometimes warranted. Various papers of value and interest were read and discussed, and numbers of specimens were shown, often accompanied by remarks which might have been characterized as "papers." Indeed, as a rule, there was rather an excess of subjects to occupy the time available at each meeting.

Amongst the papers may be mentioned, "Random Notes on the English Lake District," by James White [see vol. vii., p. 334]; "Notes on the Occurrence of *Favosites* (?) (*Calamopora*) *dentifera*, Phillips," by John Young, F.G.S. [see vol. vii., p. 369]; "Geological Notes from the Land of Lorne," by Dugald Bell; "Geological Observations in the Parish of East Kilbride," by Andrew Patton, *Cor. Mem.*, with a list of Fossils compiled by James Coutts [see vol. vii., p. 309]; "The Silurian Rocks of the Girvan District," by David Forsyth, M.A., B.Sc. [see vol. vii., p. 358]; "Review of the Southern Silurian Question," by Arthur Maconnochie, collector to the Geological Survey [for a summary see vol. vii., p. 370]; "Notes on a Fossiliferous Shale near Cloch Lighthouse," by Thomas Scott [see vol. vii., p. 462]; "Preliminary Investigation into the Geology of Benderloch," by W. Anderson Smith, Ledaig; "The Silurian Districts of Leadhills and Wanlockhead," by Dr. J. R. S. Hunter, *Hon. Mem.* [see vol. vii., p. 373].

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The EXCURSIONS which took place during the spring and summer of 1884 were as follows :—

To Cathkin, Saturday, 7th April, conducted by Mr. Walter Burns.
,, Dumbarton, 26th April, conducted by Mr. John Young.
,, Paisley, 10th May, conducted by Mr. M. Blair.
,, Glen Messan and Benmore, Queen's Birthday, 22nd May, conducted by Mr. D. Wilson.
,, West Kilbride, 7th June, conducted by Mr. Dugald Bell.
,, Dalry, 21st June, conducted by Mr. John Smith.

These excursions were, as a rule, successful, but an exception was the Queen's Birthday trip, which was, in point of attendance, a miserable failure. The Council think that probably the time has come for discontinuing this excursion, as the facilities for reaching all parts of the country on the Queen's Birthday are now so great that members can hardly be expected to turn out in sufficient numbers to make it necessary to organize any special trip on that day. It has sometimes been urged that the Saturday afternoon excursions are too frequently arranged to old and familiar places, but it must not be forgotten that there is great difficulty in selecting places of geological interest which are new ground to most members, and which, at the same time, are accessible from the city in the course of a spring or early summer afternoon. Members who can suggest localities suitable for afternoon excursions would confer a favour on the Council by writing on the subject to the Hon. Secretary.

An excursion to Ailsa Craig, in company with the members of the Kilmarnock Philosophical Society, was organized for 5th June, and a large party of members availed themselves of the unusual opportunity of visiting the lonely rock.

A joint excursion with the members of the Edinburgh Geological Society was arranged to visit the line of the new Edinburgh Suburban Railway on 5th July, under the guidance of Mr. John Henderson, and proved a most interesting one to those who took part in it. The deep cuttings made through the Lower Carboniferous strata and Intrusive Traps were minutely inspected, and some most instructive sections were met with. The joint party afterwards dined together in the Waterloo Hotel, Edinburgh.

The LIBRARY continues to prosper, and on its work Mr. Sommerville, the Hon. Librarian, will submit a report. The Council, however, regret to announce that he has found the continuance of the duties incompatible with increasing business engagements, and has therefore asked that a successor be elected this evening. Members will certainly award Mr. Sommerville a hearty vote of thanks for his past services.

Of the "TRANSACTIONS" vol. vii., pt. 2, is now at press, and will, it is hoped, be ready for issue very shortly. This will bring the printing of papers up to the conclusion of the past session.

MICROSCOPE.—By the generosity of Bailie John Farquhar, one of our life members, a handsome petrological microscope was presented to the Society for the use of the members. It was constructed by Messrs. Swift & Son, of London, the well-known instrument makers, and promises to be a credit

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to its makers as well as to Bailie Farquhar and the Society. A number of accessory appliances were purchased by the subscriptions of several members. From time to time, as the need is felt, other items will doubtless be added. To the donor of the microscope and to the subscribers to the fund the thanks of members are heartily due.

Loss of Members.—One paragraph in this report can never, unfortunately, be omitted, that in which the loss of members has to be recorded. Noticeable amongst others during the year was the death of Dr. John Dougan, a member of Council, and from a very early date a member of the Society. Soon after its formation Dr. Dougan interested himself in its work, and became a most regular attendant at the meetings.

One of the Society's prominent members, Dr. J. J. Dobbie, having received the appointment of Professor of Chemistry and Geology in University College, North Wales, had to sever his intimate connection with us, and, although able to congratulate Dr. Dobbie on his appointment, the Council cannot help expressing their sense of the great loss his absence from the meetings of the Society involves.

In bringing this report to a close the Council would reiterate a wish that in the future, as in the past, the Society will continue to prosper, and that harmony and good feeling may ever prevail amongst its members.

James Barclay Murdoch, Hon. Sec.

The Hon. Treasurer (Mr. Wight) read his Report as follows:—

Report by the Treasurer for 1883-84.

Your Librarian (Mr. Sommerville) is of opinion that the property of the Society at this time may be taken at the valuation of last year, to which is to be added the microscope and accessories. The Society's stock is therefore £523 17s. 8d., against £452 14s. 11d. reported a year ago, but the expense of printing the year's *Transactions* has to be taken into account as a deduction from stock. This will leave £473 17s. 8d. as the present value of stock, the difference between which sum and the stock of last year is as nearly as may be represented by the value of the microscope.

The Treasurer reported last year 149 subscriptions and £2 10s. of arrears, besides 8 new members, in all 162. This year he acknowledges 150 subscriptions, and £2 10s. of arrears, besides 15 new members, in all 170—being a gain over last year of 8 members. The income has therefore increased by £4 from subscriptions. The capital of the Life Membership Fund has been increased by £5 5s., and it now stands at £120 15s., the income from invested funds being nearly £10 per annum.

Receipts from Subscriptions have amounted to,				£90	5 0
Do.	from Interest,			9	15 10
Do.	from Publications sold,			7	2 3
	Total,			£107	3 1
The *Transactions* have cost,		£91	15 6		
The ordinary expenses of administration,		59	8 10		
				151	4 4
	Difference,			£44	1 3

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This difference has been paid out of cash in bank on deposit receipt, which last year was £56 and is now only £2.

It is probable that if the current income amounts to £100, and it is almost certain to do so, it will meet the expense of ordinary management, and also the expense of printing last year's *Transactions* if not more than £50. The Society's finance is now, therefore, in such a position that each year's income may be appropriated by each year's expenditure without being mixed with previous years, and this is a state of matters it is very desirable should continue.

JOHN WIGHT, Hon. Treasurer.

The HON. LIBRARIAN (Mr. Sommerville) gave his Report on the state of the Library as follows :—

REPORT ON THE LIBRARY, 1883-84.

I have much pleasure in reporting that the Library has, as in previous years, been well taken advantage of by the members. The newer books have especially been much sought after, and this is not to be wondered at when we consider that geological science is so progressive. The older works are, of course, still found of use, but more historically than otherwise.

There can be little doubt that the want of a catalogue prevents the Library being used to the extent it ought to be. The difficulty in accomplishing this matter is greater than those unacquainted with the details may imagine. There are in the collection several hundreds of volumes treating generally of the science, and a catalogue of these could easily be made and arranged. But there is a mass of valuable papers on geological details scattered through the Transactions and Proceedings of Societies, and to make these available for the use of members who are studying any particular subject they should be catalogued and classified, a work which would be vastly more useful than merely the cataloguing of the 200 or 300 volumes.

Few books were purchased during the past session, but donations of volumes and papers were made by Professor Rupert Jones, Dr. Hunter, Mr. Glen, Mr. Young, Mr. Thomson, and others. Exchanges with other societies still continue, the most noteworthy additions from this source being those from America. I have great pleasure in making special reference to the excellent monograph on the Grand Canon District, by Captain Dutton; also to the admirable Reports on the Geology of the United States, by Major Powell, and the Geology of the State of Wisconsin, by Mr. Chamberlain. As no part of the *Transactions* was issued this year my work was considerably lighter than it had been in the two previous ones.

The sale of back parts of our *Transactions* brought in £7 2s. 3d., and the total amount received from this source during my three years' term of office has been no less than £21 9s. 4d., after deduction of the usual 25 per cent. discount.

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In taking leave of my office I have to thank the Council and the members for their indulgence extended to me. My spare time has been so limited that I have been unable to devote to the Library the attention which I wished to give and which it deserved to receive.

JOSEPH SOMMERVILLE, Hon. Librarian.

The election to fill, for three years, the vacancies occurring amongst the office-bearers was then proceeded with, with the following results :—

As President, Sir William Thomson, F.R.S., etc. ; as Vice-President, Mr. D. C. Glen, F.G.S. ; as Members of Council, Mr. Dugald Bell, Mr. William Armour, Mr. John M. Campbell, and Mr. James Anderson ; as Hon. Secretary, Mr. James B. Murdoch, F.R.Ph.S.E. ; as Assistant Hon. Secretary, Mr. Gavin M. Pratt ; as Hon. Treasurer, Mr. John Wight, C.A. ; and as Hon. Librarian, Mr. James White.

The election of Mr. White as Librarian having left a vacancy in the Council Mr. Matthew Blair was elected for two years.

The following gentlemen were elected Ordinary Members of the Society :— Mr. Charles C. Bone, C.E., 23 Miller Street ; Mr. Robert Gill, 117 West George Street ; Mr. John Howat, 363 New City Road ; Mr. J. B. M'Donald, C.E., 74 Hutcheson Street ; Mr. William Petrie, 17 Steven Street ; Mr. George W. Walker, 10 Airlie Terrace, Pollokshields.

Mr. ROBERT DUNLOP exhibited, with remarks, a number of fine specimens of Fossil Fish remains from the Airdrie shale beds in the Upper Carboniferous series, including *Ctenodus cristatus* and *C. obliquus*. Mr. JAMES THOMSON, F.G.S., and Mr. JOHN YOUNG, F.G.S., also made some observations.

Mr. JAMES COUTTS exhibited specimens of Spines of *Ctenacanthus*, *Homocanthus*, and *Leptacanthus*, also *Orthoceras subcentrale*, all from the cement limestones of East Kilbride, and in the collection of Mr. A. Patton.

Mr. D. C. GLEN, F.G.S., *V.P.*, read some notes on his recent trip to Canada and the United States to attend the Meeting of the British Association at Montreal, and exhibited a number of mineral and rock specimens of interest illustrative of his remarks.

SOCIETY'S ROOMS, 207 BATH STREET.

11TH DECEMBER, 1884.

Mr. D. C. GLEN, F.G.S., *Vice-President*, in the Chair.

Mr. DAIRON read a report upon the Society's Collection of Specimens, with a scheme for its re-arrangement, upon which Mr. James Thomson, F.G.S., made some remarks. After some discussion the subject was postponed for further consideration.

Dr. J. J. Dobbie, Professor of Chemistry and Geology, University College, North Wales, was elected a Corresponding Member ; Mr. J. J. Alexander, 43 West Regent Street ; Mr. Thomas Davidson, 41 St. Enoch

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Square; and Mr. William Simmons, 70 Forth Street, East Pollokshields, were elected Ordinary Members of the Society.

Mr. ROBERT DUNLOP exhibited specimens of *Cœlacanthus lepturus*, from the shales of the Airdrie Upper Carboniferous series, and made some remarks upon its occurrence, as did also several other members.

Mr. JAMES THOMSON, F.G.S., exhibited a number of fine specimens from various localities in the United States, showing crystalline structure, and read a series of notes on a trip he had made through the territory of Idaho, to the mining region of Atlanta Mountain, during the past autumn. [For a summary see page 173.]

Mr. JOHN YOUNG, F.G.S., *V.P.*, exhibited specimens of Brucite, a native hydrate of magnesia. This mineral is found filling veins in a serpentine rock at Swenee Ness, Balta Sound, Unst, Shetland, and is of a pale sea-green colour, with a pearly lustre. It is transparent and soft, and splits into thin laminæ, which are flexible. It is composed chemically of 69·75 parts of magnesia with 30·25 of water, and is the purest native condition of the mineral which is known. It is rather rare, and only some eight or nine localities are as yet given for it, that of the specimen shown being one of the oldest and best known. Brucite is believed to be derived from the magnesian element which enters into the composition of the serpentine rocks, and which, dissolved out by water passing through them, and carried into fissures, assumes its pure crystalline form. The specimens exhibited were presented to the Hunterian Museum by Mr. J. H. Fullarton, M.A., B.Sc.

Mr. MATTHEW BLAIR read a paper entitled "Notes of a Visit to the Prairies and Rocky Mountains of Canada."

Mr. Blair's paper was illustrated by a fine Geological Map of Canada, presented to the Society by the Geological Survey of Canada, through Mr. James Thomson, F.G.S.

SOCIETY'S ROOMS, 207 BATH STREET.

8TH JANUARY, 1885.

Mr. JOHN YOUNG, F.G.S., *Vice-President*, in the Chair.

Mr. William Macrone, 28 St. Enoch Square, and Mr. Edward Westwood, 137 Ingram Street, were elected Ordinary Members of the Society.

Mr. JOSEPH SOMMERVILLE moved that a sum of £10 from the Society's funds be devoted to the purposes of the Library, which was unanimously agreed to.

Mr. ROBERT DUNLOP exhibited several species of Fish from the Airdrie shale beds, also several from the Carboniferous strata at Annick Lodge, Ayrshire. The only new species seemed to be one of *Megalichthys*, which had been seen by Dr. Traquair, but had not yet been determined.

Mr. ROBERT CRAIG, Langside, Beith, *Cor. Member*, exhibited specimens of teeth of *Rhizodus* from the Clayband Ironstones of the Beith Carboniferous series, and of very unusual size. Some remarks on these interesting

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specimens were made by the Chairman, by Mr. James Thomson, F.G.S., and others.

The CHAIRMAN (Mr. Young) exhibited specimens, sent by Mr. George Lamb, of Silurian Schist of the Bala series, from Dolgelly, North Wales, and which contained an appreciable quantity of gold.

Mr. ROBERT CRAIG, Langside, Beith, *Cor. Member*, read a paper "On the Upper Limestones of North Ayrshire" [see page 28], illustrated by a sectional map of the district.

Mr. JAMES THOMSON and the CHAIRMAN made some remarks on the subject of this paper, congratulating the Society on the reception of another valuable paper from Mr. Craig regarding a district he had made so thoroughly his own.

Mr. D. C. GLEN, F.G.S., exhibited under the Society's microscope specimens of Star Mica (*Phlogopite*) from Canada, remarking that, so far as he knew, the peculiar characteristics of the mineral, which he pointed out, were not described in any of the text-books, but had been recently illustrated and described by a writer in *Science Gossip*.

SOCIETY'S ROOMS, 207 BATH STREET.

12TH FEBRUARY, 1885.

Mr. DAVID FORSYTH, M.A., B.Sc., *Vice-President*, in the Chair.

Mr. J. H. Fullarton, M.A., B.Sc., Natural History Rooms, University of Glasgow, was elected an Ordinary Member of the Society.

Mr. ROBERT DUNLOP exhibited a further selection from his collection of Fish Remains from the Airdrie shale-beds, with remarks, which were supplemented by Mr. John Young, F.G.S., and Mr. James Thomson, F.G.S.

Mr. DANIEL WILSON exhibited samples of Copper-bearing Rocks from Aberystwith, Cardiganshire, North Wales, some of which contained by assay about 28 per cent. of copper, and therefore compared favourably with the recent produce of Cornish lodes.

Mr. JOHN KIRSOP, F.S.A.Scot., exhibited, with remarks, a fine series of remains of Fossil Fish from the flagstones of Caithness, belonging to the Lower Old Red Sandstone group. Of these Caithness flags Sir Richard Owen once wrote that they owe their peculiar and valuable qualities of density, tenacity, and durability, wholly to the dead fish that rotted in their primitive mud. Mr. Kirsop also exhibited a beautiful specimen of a Fossil Fish from Ottawa, Canada, by the kindness of Mr. Spence Bates, of Plymouth, but the genus and species were undetermined.

Mr. JOHN YOUNG, F.G.S., gave some explanatory particulars regarding these specimens of fish.

Mr. MATTHEW BLAIR exhibited a specimen of the Prairie Coal of North-West Canada, said to be of Tertiary age, its range extending over hundreds of miles; also a specimen of Carboniferous Coal from New Glasgow, Nova Scotia, where the seam is 18 feet in thickness. New Glasgow, Mr. Blair said, is at present only a small town, but from its

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proximity to great mineral wealth, it is evidently destined to become at no distant date a place of importance. Judging from the names over the shops, he could almost have believed himself to be in *Old* Glasgow.

Mr. DUGALD BELL read a paper entitled "Notes on some Recent Excursions of the Society," in which he touched upon a number of interesting points in connection with various of these gatherings. He remarked incidentally that he thought it would be a feature of interest, if, as a matter of course, the excursions were recorded and shortly described during the session following their occurrence. Mr. Bell's paper was illustrated by several sheets of the Geological Survey map.

Mr. JOHN KIRSOP submitted, for the consideration of the meeting, the theory advanced by Prof. Cope Whitehouse, of the United States, that Fingal's Cave, Staffa, is not of natural, but of artificial origin. It was, however, thought to be too absurd to permit of discussion.

SOCIETY'S ROOMS, 207 BATH STREET,
12TH MARCH, 1885.

Mr. D. C. GLEN, F.G.S., *Vice-President*, in the Chair.

Mr. Loudon M. Douglas, Chemist, 20 Canal Bank, was elected an Ordinary Member of the Society.

Mr. JOHN KIRSOP, F.S.A.Scot., exhibited various Mammalian Remains from the phosphate deposits of Beaufort River, U.S., comprising Teeth of *Mastodon*, *Elephas*, and one or two Ruminants; Bones belonging to the same group, and a fragment of Deer's Horn.

Mr. JOHN YOUNG, F.G.S., remarked that the fact that such remains were found largely intermingled with marine organisms showed that they must have been brought down by the action of some great river from land existing at the time when these now extinct animals lived.

Mr. JOHN YOUNG read a paper on the remarkable structure known as "Cone-in-cone." [See page 1.] An interesting discussion on Mr. Young's paper was taken part in by Messrs. Thomson, Forsyth, Anderson, Bell, Murdoch, and others. Most of the speakers thought that Mr. Young's theory was reasonable and natural, and that therefore he had contributed more towards the dispelling of the obscurity attending the formation of Cone-in-cone than any previous observer.

SOCIETY'S ROOMS, 207 BATH STREET,
2ND APRIL, 1885.

Mr. JOHN YOUNG, F.G.S., *Vice-President*, in the Chair.

Some remarks on the question of accommodation of the Museum were made by Mr. James Thomson, F.G.S., after which it was formally moved

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and agreed that the Committee be thanked for its labours and discharged, and that no further action in the matter be taken in the meantime.

Mr. William Muir, 3 North Street, Anderston, and Mr. Hugh Wilson, 35 Raeberry Street, were elected Ordinary Members of the Society.

Mr. ROBERT DUNLOP exhibited a large series of Plant Remains from the Carboniferous shales of the Airdrie district, and read a paper descriptive of them by Mr. Robert Kidston, F.G.S., Stirling. [See page 47.] Several of the genera and species were new to Scottish strata.

Mr. JOHN YOUNG, F.G.S., Vice-President, exhibited specimens of Actinolite and Anthophilite which he had received for the Hunterian Museum from Mr. Arthur Macconochie, Edinburgh, Collector to the Geological Survey. They were obtained in Durness, Sutherlandshire, and were doubtless only varieties of Amphibole or Hornblende.

SOCIETY'S ROOMS, 207 BATH STREET,
14TH MAY, 1885.

Mr. D. C. GLEN, F.G.S., *Vice-President*, in the Chair.

Mr. William Campbell, Seafield Cottages, Claythorne, Partick, was elected an Ordinary Member of the Society.

Mr. JAMES COUTTS read "Notes upon the bed of Intrusive Dolerite exposed in the channel of the Clyde at Elderslie, and the work of its removal." Mr. Coutts' paper was illustrated by specimens of the rock, and cores from the bores put down for blasting purposes, also by a geological map of the district.

Mr. WILLIAM JOLLY, F.G.S., read a paper entitled "The Parallel Roads of Lochaber: the Problem, its Conditions and Solutions." [For a Summary see page 40.] The paper was extensively illustrated by maps, sections, and diagrams.

SOCIETY'S ROOMS, 207 BATH STREET,
28TH MAY, 1885.

Mr. DAVID FORSYTH, M.A., B.Sc., *Vice-President*, in the Chair.

Mr. MURDOCH (Hon. Secretary) gave some explanations as to the forthcoming meeting of the Mineralogical Society of Great Britain in the Society's Rooms, on the 16th of June proximo, and stated that an invitation to be present at the meeting had been given to all members of the Society. Mr. Murdoch also spoke of the arrangements regarding the joint excursion with the members of the Edinburgh Geological Society to Bathgate, on 6th June proximo. He further gave some particulars as to a proposed exchange of specimens of minerals, etc., between members of the Society and Prof. Bombicci, of Naples, which had been arranged by Mr. George R. Alexander on his recent visit to Italy.

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Dr. J. R. S. HUNTER, F.R.Ph.S.E., *Hon. Member*, read two papers, as follows:—(1) "Notes on the Discovery of a Fossil Scorpion, *Caledonicus Palæophonus*, in the Silurian Strata of Logan Water." [For a Summary see p. 169.] (2) "The Old Red Sandstone of Lanarkshire, with notes on volcanic action during Old Red and Carboniferous Times, with an exhibition of the head of *Cephalaspis Glottensis* from the Lower Old Red Sandstone of Lesmahagow." [See page 161.]

In the course of some remarks by Mr. JOHN YOUNG upon these papers, he suggested that the *Cephalaspis* should be called *C. Lyelli*, variety *Glottensis*.

The CHAIRMAN (Mr. Forsyth) also made some observations.

Mr. JAMES THOMSON, F.G.S., said that before the meeting closed he wished to be allowed to exhibit a specimen of Limestone taken from a large block in the Borland Burn on the Marnock Water, which showed Cone-in-cone structure. While accepting generally Mr. Young's theory of the origin of Cone-in-cone, as given in his paper read at last meeting, he did not believe that it could account for the presence of radiation of the structure of Cone-in-cone from a centre, as shown in the mass of which the specimen now exhibited formed a part.

Mr. YOUNG, in reply, said that as the specimen Mr. Thomson brought forward did not in itself show the appearance of radiation of Cone-in-cone structure from a centre said to be found in the parent block, he could not accept Mr. Thomson's conclusions without further evidence.

After some discussion, the meeting agreed to defer passing any expression of opinion on the subject in the meantime, and requested Mr. Thomson to bring up at an early meeting in the coming session a larger specimen of the limestone, showing in itself distinct radiation of Cone-in-cone from a common centre.

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PROCEEDINGS FOR SESSION 1885-86.

(28TH SESSION.)

SOCIETY'S ROOMS, 207 BATH STREET,

15TH OCTOBER, 1885.

Mr. JOHN YOUNG, F.G.S., *Vice-President*, in the Chair.

The CHAIRMAN said, in opening the first meeting of a new session he hoped and believed that as good work would be done by the members in the future as had been done in the past, and urged that those who were able to contribute papers and specimens for forthcoming meetings should not be backward in bringing them forward, so as to increase the interest of the meetings, and at the same time lighten the work of the Secretaries.

Mr. JAMES COUTTS read "Notice of the late Mr. Andrew Patton, *Cor. Member*, East Kilbride," in which he gave a short account of Mr. Patton's life and work, proposing, in conclusion, a vote of condolence with his widow and family. [See page 171.]

The CHAIRMAN said that he could endorse all that Mr. Coutts had said respecting their deceased friend. He was an ardent and intelligent collector, and a good type of a class to be met with in various localities of the West of Scotland, many of them being men whose natural abilities and tastes had been stimulated and encouraged in the right direction by their intercourse with members of the Society.

Mr. JAMES WHITE read a paper entitled "Notes on Tarbert, Argyllshire." [See page 171.]

Dr. M. F. HEDDLE, of St. Andrews, gave some interesting details regarding various of the rarer Western Scottish minerals, including Edingtonite, Greenockite, Thomsonite, Heulandite, and others, referring more particularly to those of which the localities are at present unknown, and remarking that members who took an interest in mineralogy should not lose any opportunity of re-discovering the lost localities in the cause of science as well as for their own personal advantage.

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SOCIETY'S ROOMS, 207 BATH STREET,

12TH NOVEMBER, 1885.

ANNUAL GENERAL BUSINESS MEETING.

Mr. D. C. GLEN, F.G.S., *Vice-President*, in the Chair.

The HON. SECRETARY (Mr. Murdoch) then read as follows :—

THE REPORT OF THE COUNCIL FOR 1884-85.

Your Council have again the pleasure of laying before the Society their annual report on the work of another session, and are glad to be able to speak favourably of the past and hopefully of the future.

The MEMBERSHIP has during the year gone by remained at about its recent level, the number of deaths and resignations being nearly balanced by the accession of new members. Though this state of matters is so far satisfactory, yet the Council would rejoice to see an increase in the roll of membership, and therefore express a hope that every individual member will do his best to add to the number.

The FINANCES are, as your Hon. Treasurer will inform you, in a sound and healthy condition.

The MEETINGS of the past session were nine in number, and were attended by quite the usual average—about one-fourth of the total membership—which, taking into account the many attractions now-a-days held out for evening amusement or instruction, may be considered as a remarkably good one.

The PAPERS and SPECIMENS submitted to the meetings were, as a rule, of much interest. Amongst the former may be enumerated the following :—"Another Glimpse of Skye," by Mr. James White ; "Notes of a Visit to the Prairies and Rocky Mountains of Canada," by Mr. M. Blair ; "The Upper Limestones of North Ayrshire," by Mr. Robert Craig, *Cor. Member ;* "Notes on Recent Excursions of the Society," by Mr. Dugald Bell ; "On Cone-in-Cone Structure," by Mr. John Young, F.G.S., *V.P.* ; "On Plant Remains from the Airdrie Shales," by Mr. Robert Kidston, F.G.S. ; "On the Parallel Roads of Lochaber : the Problem, its Conditions and Solutions," by Mr. William Jolly, F.G.S. ; "Notes on the Discovery of a Fossil Scorpion in the Silurian Strata of Logan Water" and "The Old Red Sandstone of Lanarkshire," by Dr. J. R. S. Hunter, *Hon. Member*. Most of those papers will, it is hoped, be printed along with these of the present session in the forthcoming part of the Society's *Transactions*, which is now preparing for press.

THE EXCURSIONS of the session were as follows :—

To Arkleston, Paisley, on Saturday, 18th April, conducted by Mr. M. Blair.

To Boyleston, Barrhead, on Saturday, 2nd May, conducted by Mr. D. C. Glen, F.G.S.

To Corrieburn, on Saturday, 16th May, conducted by Mr. John Young, F.G.S., *V.P.*

To Trearne, Beith, on Saturday, 30th May, conducted by Mr. Robert Craig.

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To Lochlomondside, on Saturday, 13th June, conducted by Mr. Dugald Bell.

They were all well attended, some of them numerously so. Perhaps the last-mentioned was the one most appreciated, partly on account of its greater novelty, being made to a locality not previously visited by the Society. On this occasion the party was hospitably entertained at Arden House by Mr. James Lumsden, F.Z.S.

A Joint Excursion with the members of the Edinburgh Geological Society, now considered to be one of the standing events of the year, was arranged to be made to Bathgate on the 5th June, under the leadership of Mr. John Young, F.G.S., but in his unavoidable absence from indisposition, Mr. James Bennie of the Geological Survey conducted the party. The very enjoyable day was wound up by a dinner at the Bathgate Royal Hotel.

Another excursion, and one inaugurating quite a new departure, was one arranged to take place jointly with the members of the Edinburgh Geological Society to Lochaber and the Parallel Roads of Glen Roy, during the last week of July, under the leadership of Mr. William Jolly, F.G.S. It extended over a full week, and of the twenty men who took part in it not one had reason to look back upon it with anything but pleasurable feelings. During the six days at the disposal of the party much ground was gone over and many interesting facts were brought under notice. First an ascent of Ben Nevis at night and descent in the early morning, and secondly a close inspection of the wonderful "Roads" and the splendid glaciation of the district. Before the party broke up a wish was generally expressed that similar excursions might in future years be organized to other districts of geological interest.

The LIBRARY has during the past year been considerably added to, both by donation, exchange, and purchase. Great progress has also been made in bringing it into good working order, as will be seen from your Hon. Librarian's Report, to be submitted this evening.

Of the TRANSACTIONS, a new part, the largest yet issued, was sent out to members early in the past summer. That to follow (Part I of Vol. VIII.) is just preparing for the printer, and will contain the papers of last session, as well as those of the present one.

THE DEATH OF MEMBERS.—As is unhappily usual in this Report your Council have to note the loss of several members more or less prominent in the Society's work. Mr. Andrew Patton, of East Kilbride, a *Corresponding Member*, whose fine collection of fossils from the Kilbride Cementstone Series has so often been laid under contribution to grace the exhibitions of our meetings, through the agency of Mr. James Coutts, died early in summer, and Dr. Thomas Davidson, of Brighton, one of our *Honorary Members*, whose great work amongst the Brachiopoda is known to every palæontologist, died last month. More than an expression of deep regret at their removal from amongst us need not here be made, as notices of both will appear in the *Transactions*, the former, by Mr. Coutts, having been read at last meeting, while the latter is to be given by Mr. Young in the course of this evening.

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Mr. JOHN WIGHT, C.A., Hon. Treasurer, then read as follows :—

REPORT BY THE TREASURER FOR 1884-85.

The income of the Society maintains the steady position it has occupied for a good many years. The last Report exhibited an income from subscriptions of £75 from 150 members on the roll when the session opened, besides £2 10s. for arrears and £7 10s. from 15 new members, in all £85. During the year just ended an equal influx of new members has occurred ; the same sum of arrears has been recovered ; and 150 subscriptions have been paid, in all £86 10s., showing a difference of £1 10s. in favour of the present year. So far, therefore, as ordinary revenue from subscriptions is concerned the Society is maintaining its ground, and that without any particular effort. Last year produced a revenue from invested funds of £9 15s. 10d., which item this year amounts to £10 0s. 5d.

The accounts have now fallen into a methodical shape, and we may compare year by year the two branches of expenditure into which the payments are divided—that is to say, the ordinary normal expenses, and the expense of publications. Last year we paid £59 8s. 10d. for every kind of expense attending management, but that sum must have included more than a year's, perhaps more than two years', expense for printing cards and circulars, because the amount paid under that head was so high as £28 11s. 6d. Everything else was normal, and the Collector's commission, including postages and petty expenses, was £4 8s. 6d. The present year shows a total expenditure of £43 16s. 8d. only under this branch. The Treasurer is desirous, as he formerly remarked, to charge each year's revenue with the same year's expenditure, and it is evident from the figures that this point has now been nearly attained.

The cost of printing the *Transactions* published at the close of last session has not yet been paid, except for lithographing the plates. The amount is past due and will be paid now, and it is entered in the Accounts as a charge against the Society's capital stock ; the other debts, chiefly for printing cards and circulars, are supposed to come within £12. The Society's property, then, is held to be fairly valued at £561 17s. 5d., and after deducting the debts the net amount is £475 3s. 5d. The net stock last year was given up at £483 17s. 8d., a difference of £8 14s. 3d. against the year 1885.

The Treasurer reported last year that he expected the Society's income this year to be £100, and he was nearly right, because it has realized £96 10s. 5d. He also mentioned that if the cost of the *Transactions* then in hand was only £50, ordinary revenue would meet all the expense. But he has shown that the cost is £74 14s., and that the net capital stock of the Society is only £8 14s. 3s. less than the net capital stock of the Society a year ago. It therefore follows that the Treasurer's expectations have been realized beyond the extent of his anticipations, because ordinary revenue has paid for the *Transactions*, not at £50 but at £74 14s., with exception only of this sum of £8 14s. 3d.

The life subscription fund rests at £120 15s.

JOHN WIGHT, Hon. Treasurer.

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Mr. JAMES WHITE, Hon. Librarian, then read his Report on the state of the Library for 1884-85, from which it appeared that while a good deal of work had been done much more remained to be done, and some expense would have to be incurred before the Library assumed a satisfactory condition.

All these reports were unanimously approved of and adopted, and a cordial vote of thanks was awarded to the Hon. Treasurer, Hon. Librarian, and Hon. Secretaries for all the time and trouble they had expended on behalf of the Society during the past year.

Mr. WHITE proposed that an additional £10 should be granted for the use of the Library during the present year, and this was unanimously agreed to.

The election of office-bearers was then proceeded with, the result being as follows :—

As Vice-President, Mr. William Jolly, F.G.S.; as Members of Council, Messrs. David Forsyth, Joseph Sommerville, Charles L. Dobbie, and John Farquhar. Messrs. John Robertson and George R. Alexander were re-elected Auditors for the current year.

Mr. JAMES B. MURDOCH (Hon. Secretary) exhibited two Caudal Vertebral Bones of a Cetacean, which had recently been dug up from under a bed of peat at a depth of about ten feet, in the neighbourhood of Rumbling Bridge, Perthshire, and from a higher level above the sea than whale remains had previously been discovered at. The species to which they belonged had not yet been determined.

Mr. WILLIAM JOLLY, F.G.S., *Vice-President*, read an account of the joint excursion by the members of the Glasgow and Edinburgh Geological Societies to Ben Nevis and Glen Roy with its Parallel Roads, during the last week of the past July. [See page 72.] The paper was illustrated by a series of maps and diagrams.

Owing to the lateness of the hour discussion on Mr. Jolly's paper, as also a Notice of the late Dr. Thomas Davidson, of Brighton, by Mr. John Young, F.G.S., had to be postponed to the following meeting.

SOCIETY'S ROOMS, 207 BATH STREET,

10TH DECEMBER, 1885.

MR. WILLIAM JOLLY, F.G.S., *Vice-President*, in the Chair.

The following gentlemen were elected members of the Society :—As Honorary Member, Dr. M. Foster Heddle, F.R.S.E., St. Andrews. As Ordinary Members, Mr. John Clark, Gushetfaulds; Mr. James Hamilton, Mining Engineer, 92 North Frederick Street; Mr. George E. Henderson, Assistant to Professor of Chemistry, University, 1 Westbourne Terrace, Kelvinside; Mr. Robert More, Stationer, 505 Sauchiehall Street; Mr. James T. Tullis, The Anchorage, Burnside; Mr. David Tullis, Glencairn, Burnside.

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Mr. J. B. MURDOCH (Hon. Secretary) exhibited a specimen of Ilmenite or Titaniferous Iron, a hematite with part of the iron replaced by Titanium, from Arrochar, Loch Long, but only found there in boulders. Mr. John Young, F.G.S., said that when on an excursion last year to the head of the Holy Loch, and on a road near Benmore House, he had found the mineral *in situ*, in vein quartz.

Mr. YOUNG exhibited a specimen of Ambrite or Fossil Resin found in Tertiary coal in New Zealand; also a specimen of "Kauri Gum," a sub-fossil resin supposed to be derived from pine trees of a bygone time and now found by professional diggers of the substance in the soil of certain localities of New Zealand.

Mr. YOUNG also exhibited a specimen of *Psilotites unilateralis*, Kidston, from Carboniferous Shale raised at one of the coal-pits near Baillieston.

Mr. YOUNG read a notice of the late Dr. Thomas Davidson, of Brighton, more especially as connected with his lifework amongst the Brachiopoda of the West of Scotland, proposing that an expression of condolence should be sent to Dr. Davidson's widow. This was unanimously agreed to. [See page 138.]

The adjourned discussion on Mr. Jolly's paper on the Parallel Roads of Glen Roy, was then taken up, remarks being made by Messrs. Jolly, Young, Renwick, Thomson, Murdoch, and others.

SOCIETY'S ROOMS, 207 BATH STREET,

14TH JANUARY, 1886.

MR. JOHN YOUNG, F.G.S., *Vice-President*, in the Chair.

The HON. SECRETARY read a letter he had received from Dr. Heddle, with a large parcel of his various writings upon Mineralogy, which he begged the Society to accept as a small acknowledgment of the honour done him by his election as Honorary Member. Dr. Heddle further offered to deliver two lectures to members and their friends, "On Carbonic Acid in Nature as illustrative of Design." This offer was warmly accepted, and the Council was asked to make the needful arrangements.

Mr. JOHN DOUGAN exhibited a specimen of Coal from Langloan, showing a peculiar collapsed spheroidal structure.

Mr. D. C. GLEN, F.G.S., *V.P.*, exhibited, with remarks, as follows :—

(1) Kerosene Shale, or Australian "Boghead," from New South Wales.
(2) Schorliferous Granite, from Rubislaw, Aberdeenshire, and Portsoy, Banffshire.
(3) Serpentine and Marmolite (polished), from Portsoy.
(4) Crystals of Greenockite or Sulphide of Cadmium, a slide containing upwards of 30 small crystals, exhibited under the Society's microscope.

Mr. JOHN YOUNG, F.G.S., and other members made explanatory remarks.

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Mr. J. B. MURDOCH (Hon. Secretary) read a paper entitled "Notes upon the Recent Meeting of the British Association at Aberdeen." [For a Summary, see page 179.]

Mr. WILLIAM JOLLY, F.G.S., *V.P.*, said that, at the late hour of the evening, it would be impossible to go into either of the important subjects touched upon in Mr. Murdoch's paper; but, as regarded the North-West Highlands, he might say that he had been asked to give a paper to the Edinburgh Geological Society, with the view of organizing an excursion to Loch Maree, a district where the disputed rocks could be studied to advantage, in the course of next summer, and that, if the meeting approved, he would be glad to read it before the Glasgow Society also. Mr. Jolly's offer was cordially accepted.

SOCIETY'S ROOMS, 207 BATH STREET,

11TH FEBRUARY, 1886.

MR. WILLIAM JOLLY, F.G.S., *Vice-President*, in the Chair.

Mr. John D. Crockatt, mining engineer, Annan Villa, Falkirk; and Mr. James Hugh, clerk, Nelson Cottage, Langside, were elected Ordinary Members of the Society.

Mr. A. C. MACINTYRE exhibited a fine specimen of Malachite which had been lately found on Croy Hill, Dumbartonshire. How it had reached that locality was, however, a matter for speculation, as it was clearly not native. Mr. John Young said that he thought it had every appearance of being a true Russian or Australian specimen.

Mr. JOHN BUCHANAN exhibited specimens of Iron Pyrites, Calc Spar, Galena, etc., from Leadhills, Lanarkshire; and on them Mr. John Young, F.G.S., made some interesting explanatory remarks.

Dr. JAMES THOMSON, F.R.S.E., Professor of Engineering in the University of Glasgow, read a paper entitled, "On Crystallization and Liquefaction as influenced by stresses in the crystals, with special reference to metamorphic changes in rocks and to plasticity of ice." Professor Thomson explained his theory of crystallization and liquefaction as influenced by stresses that lead to change of form in the crystals. Taking, for example, the case of crystals of ice, he showed that any stresses whatever tending to change the form of a piece of ice in ice-cold water must impart to the ice a tendency to melt and to give out its cold, which would generate from the surrounding water a corresponding quantity of ice free from the applied stresses. This newly formed ice would in due time come to undergo the straining action, and then to melt, the action of glacier ice being thus accounted for.

This theory of the plasticity of ice and the motion of glaciers, Professor Thomson offered in place of his now well-known theory, which he gave in December, 1861, in a paper to the Royal Society (of London), and which many years ago he had almost entirely withdrawn. In the course of his

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paper, he submitted for examination, and made some remarks on, the impressed limestone pebbles which, about the year 1862, had been under the careful scrutiny of Mr. H. C. Sorby, as he held that the theory he now presented afforded a satisfactory explanation of their peculiar impressed and indented appearance. Professor Thomson also showed specimens of distorted and metamorphozed quartzite pebbles from the Ballinton beds, near Aberfoyle. Also, a series from Prescott, kindly furnished to him by Dr. Ricketts, F.G.S., Birkenhead, which appeared to have been in a semi-plastic condition, each one having been impressed into its contiguous neighbours. The metamorphic changes in these conglomerates, as also metamorphic changes in many other kinds of rocks, might, he thought, have an explanation applied by means of the theory he had propounded.

Mr. John Young, F.G.S., *V.P.*, Mr. D. Forsyth, and the Chairman (Mr. Jolly) having given expression to their views, Professor Thomson received a hearty vote of thanks for bringing his paper before the Society.

SOCIETY'S ROOMS, 207 BATH STREET,

11TH MARCH, 1886.

MR. D. C. GLEN, F.G.S., *Vice-President*, in the Chair.

Mr. WILLIAM CAMPBELL exhibited a Fossil Starfish from the Brick Clay-beds of Jordanhill, and remarked that the Brick-clays of Jordanhill, of which two distinct beds are seen, occupy a hollow in the Boulder-clay averaging about half a mile in breadth, and extending in a north-westerly direction for several miles, the beds at Dalmuir being probably a continuation of them. The upper bed is about 8 feet in thickness, and is reddish in colour, with few or no shell remains, but having a reed-like plant abundantly through it. The lower bed varies in depth according to the undulations in the surface of the underlying Boulder-clay, and is of a deep blue colour. In it shells, many of species still living in our seas, abound, and also the reed-like plant of the upper bed. In one of the lowest layers of this bed Mr. Campbell found the Starfish now exhibited, and thought that it also, like many of the mollusca in the bed, might be of an existing species, but this seems not to be the case, as it does not agree with any of the specimens of recent Starfish in the Hunterian Museum, the most important difference being that, while the plates of recent species terminate in several spines, in this one the spines are entirely absent.

The specimen had been submitted to Mr. David Robertson, F.L.S., who informed Mr. Campbell that he "had not seen one from the Clyde Valley with the outline so well preserved"; and went on to say that, "throughout our Post-tertiary beds, both in the East and West of Scotland, plates of Starfishes are found not uncommonly scattered through the clay; and there is little doubt that some of these scattered plates belong to the same genera or species as the one sent me. This, however, cannot well be ascertained without breaking up the specimen and washing the plates, but it would be a great pity to destroy such a fine specimen."

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Mr. JAMES PRENTICE exhibited a specimen, showing the deposition and crystallization of Bisulphide of Iron on Sandstone, from Messrs. Black's ironstone mines, Stanrigg, Airdrie. It was found in a fissure of the roof of the slatyband ironstone 905 feet from the surface of the ground. Dr. Heddle, Mr. John Young, F.G.S., *V.P.*, Mr. James Thomson, F.G.S., and other members, spoke regarding this interesting specimen.

Mr. ROBERT DUNLOP exhibited a specimen of *Calamitina*, a fossil plant from the Lanarkshire Coalfield, closely allied to *Halonia*.

Mr. JOHN HOWAT exhibited a series of Carboniferous Fossils, from Poolvash Bay, Isle of Man, some specimens of *Goniatites* being unusually fine. Dr. Heddle, Mr. James Thomson, and other members, pointed out some of the peculiarities of the collection.

Mr. JOHN YOUNG, F.G.S., *V.P.*, read a paper, entitled, "Notes on the Carboniferous Brachiopoda of Scotland, with a revised list of the genera and species." [See page 142.] The paper was illustrated by sections and diagrams, also by type specimens of the genera and species of Scottish Brachiopoda. Dr. Heddle, Mr. James Thomson, and other members, spoke on the subject of Mr. Young's paper, which was characterized as being very exhaustive, and likely to be of considerable use to workers amongst Scottish Brachiopoda.

SOCIETY'S ROOMS, 207 BATH STREET,

15TH APRIL, 1886.

Mr. JOHN YOUNG, F.G.S., *Vice-President*, in the Chair.

Mr. Walter Steuart, insurance agent, 12 Pollok Road, Pollokshaws, was elected an Ordinary Member of the Society.

The CHAIRMAN read a notice he had drawn up regarding the late Mr. James Coutts, one of the active members of the Society, who had been lately removed by death, and proposed that a vote of condolence with his widow should be passed, and an extract from the minutes forwarded to her by the Secretary. This was unanimously agreed to. [See page 177.]

The Chairman (Mr. Young) and Mr. Robert Mason, F.L.S., exhibited specimens of a rare Echinoderm *Allagecrinus Austinii*, Etheridge and Carpenter, from the weathered Limestone shale of Auchenskeoch, Dalry, and Gillfoot, Carluke, accompanied by some remarks by Mr. Young.

Mr. DUGALD BELL read a paper entitled "The Detached Areas of Carboniferous Deposits in Scotland," in which he gave a short account of the principal and smaller isolated coalfields so far as known to exist in the northern portion of the kingdom. An interesting discussion followed, and was taken part in by the Chairman, Mr. Forsyth, Mr. James Thomson, F.G.S., and other members.

Owing to the lateness of the hour another paper by Mr. Bell, "Some Notes on the Glaciation of the South of Scotland," was held over to a future meeting.

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SOCIETY'S ROOMS, 207 BATH STREET,

13TH MAY, 1886.

Mr. D. C. GLEN, F.G.S., *Vice-President*, in the Chair.

Mr. Robert M'Laren, H.M. Inspector of Mines, Coatbridge, was elected an Ordinary Member of the Society.

Mr. MATTHEW BLAIR exhibited, with remarks, specimens of Beechwood taken from beneath the foundation walls of St. Mirren's Church, Paisley. The logs of beech, of which the specimens exhibited were portions, had in the year 1803 been originally placed where they were found, for the purpose of supporting the building, of which the site was in a soft and boggy situation. The combined moisture and pressure seemed to have considerably altered their structure. Remarks on the interesting questions raised were made by the Chairman (Mr. Glen), Mr. Murdoch (Hon. Secretary), Mr. John Young, F.G.S., and other members.

Mr. WILLIAM JOLLY, F.G.S., *V.P.*, read a paper on "The Succession of Rocks in the North-West Highlands: the Problem, its History and Present State," giving a graphic account of the district and its salient geological features, about which so long and so fierce a controversy has raged. The age and succession of the North-West Highland rocks has now been definitely settled to be those first promulgated by the late Professor James Nicol, of Aberdeen, although for many years contrary opinions were advocated by such eminent observers as Murchison, Harkness, Sedgwick, Arch. Geikie, and others. The paper was illustrated by a number of coloured rock-sections and views, lent for the occasion by Dr. Heddle, of St. Andrews, *Hon. Member*. The subsequent discussion was taken part in by Mr. John Young, F.G.S., Mr. M. Blair, Mr. David Forsyth, and other members. Mr. Jolly, in replying, gave some particulars regarding the proposed long excursion during the last week of July to Loch Maree, for the purpose of studying on the spot the disputed succession of the N.-W. Highland rocks.

SOCIETY'S ROOMS, 207 BATH STREET,

27TH MAY, 1886.

Mr. WILLIAM JOLLY, F.G.S., *Vice-President*, in the Chair.

Mr. H. S. Hewett, 8 Milton Terrace, Langside, and Mr. John Manford, Wellfield, Partickhill, were elected Ordinary Members of the Society.

Mr. MURDOCH (Hon. Secretary) gave some further particulars regarding the joint excursion with the members of the Edinburgh Geological Society to Torbanehill and Bathgate on Saturday, 12th July; and also some details as to the long excursion to Loch Maree during the last week of the same month.

Mr. D. C. GLEN, F.G.S., and Mr. MURDOCH, Hon. Secretary, were

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appointed delegates to represent the Society at the Meeting of the British Association in Birmingham in September next.

Several photographic groups of members, taken at the recent excursion to Gleniffer, were exhibited, and names of those who wished to obtain copies were requested to be sent to the Hon. Secretary.

Dr. J. R. S. HUNTER, F.R.Ph.S.E., *Hon. Member*, read a paper entitled "The Geology of Annandale." The author confined his remarks entirely to the Permian and Carboniferous rocks, illustrating them by a considerable suite of the characteristic fossils of the district spoken of. The following discussion was taken part in by Mr. David Forsyth, M.A., Mr. Dugald Bell, and Mr. John Young, F.G.S., *V.P.*, the latter remarking that all the evidence went to uphold the theory that the Carboniferous limestone strata of Annandale lie far down in the Calciferous series.

The CHAIRMAN (Mr. Jolly) then declared the 28th session of the Society to be closed, and expressed a hope that all the members would be spared to meet again in health and spirits in the following October to begin the work of a new session, bringing with them an accumulation of observations from their summer rambles.

RECORD OF THE EXCURSION

TO THE PARALLEL ROADS OF LOCHABER IN JULY, 1885.

Our excursion, which had been long spoken of, to visit the celebrated Parallel Roads of Glen Roy, was successfully undertaken during the last week of July, 1885, by a joint party of the members of the Edinburgh and Glasgow Societies. Those gentlemen present were—Dr. Stevenson Macadam, Dr. Semple, Messrs. James Melvin, Ferguson, R. Matheson, and the Rev. Mr. Kennedy, of the Edinburgh Society; while representing this Society were—Messrs. William Jolly, David Tullis, James T. Tullis, Renwick, Horne, W. Stewart, J. B. Murdoch, and Dr. Gilmour. The party was also joined by Mr. Boyd, H.M. Inspector of Schools, Mr. T. C. Maggs, F.G.S., and Mr. Livingston, Fort-William.

Of the famous "Roads" no account need here be given, as a summary of all that has been written and said about them will be found in Mr. Jolly's paper at page 40 *antea*.

Favoured by the most glorious weather, the Glasgow party left Buchanan Street Station for Oban on Monday morning, being joined in the afternoon by the Edinburgh contingent.

At Fort-William a sudden resolution to ascend Ben Nevis was come to, and almost the whole party made the ascent, remaining in the Observatory on the top all night. The sunrise on Tuesday morning alone rewarded all their toils. With a clear and brilliant sky in all directions but the south, where a massive rain-cloud canopied all below, and resembled on its upward surface, with here and there a mountain-peak appearing through it, an ancient palaeocrystic sea, the panoramic view was superb

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beyond description. Hill upon hill, loch upon loch, were seen to the fullest possible extent, including those of Rum, Muck, Eigg, Skye, Harris, Uist, the Moray Firth, with Ben Lawers and Schiehallion. By nine o'clock the descent was accomplished, and all were *en route* for Roy Bridge Hotel, where the head-quarters of the party were. After breakfast Glen Roy was visited, and the "Roads" were minutely inspected. Wednesday was devoted to an examination of the widely-extended moraine of Roughburn, and the wonderful glaciation at the mouth of Loch Treig, with the terminal horse-shoe moraine in Glen Spean. On Thursday Coire-an-Eoin deer-forest was visited, and here again the evidences of glaciation were intense. On Friday another visit was paid to Glen Roy and Glen Colleraig, and some points bearing more particularly on statements made by Mr. Milne Home were carefully noted and recorded. On Saturday the party left with regret its pleasant surroundings, and after a long and super-heated journey, *via* Oban, reached in safety the point from which they had started on the previous Monday.

Mr. William Jolly, F.G.S., who had undertaken the conductorship of the party, proved himself to be thoroughly master of the district, and was a most admirable "guide, philosopher, and friend." Indeed, the entire success of the expedition was in great measure owing to his excellent arrangements, and before the party broke up a special vote of thanks was awarded by acclamation to him.

Many of those who were present had not previously been known to each other, but there existed throughout the utmost harmony and good fellowship, and one and all expressed a hope that the Glen Roy excursion might prove to be only the forerunner of a long series of similarly successful excursions to the more notable geological localities in Scotland. M.

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Abstract of the Treasurer's Accounts for the Year ending 30th September, 1884.

CASH ACCOUNT.

RECEIPTS.

Balance—Due by the Treasurer at close of last Account,			£1 18 11
Annual Subscriptions—			
Arrears for 1881 and 1882-83,	£2 10 0		
For current year, 150 at 10s.,	75 0 0		
New Members, 15 at 10s.,	7 10 0		
		85 0 0	
Life Membership Subscription—Mr. C. L. Dobbie,		5 5 0	
Interest—On Invested Funds,		9 15 10	
Publications Sold,		7 2 3	
Bank Account—Drawn,		56 0 0	
			£165 2 0

EXPENDITURE.

Transactions—			
Printing Part I. of Volume VII.,	£67 12 0		
Binding do.,	5 1 0		
Lithographing and Engraving,	19 2 6		
		£91 15 6	
Ordinary Expenditure—			
Printing Cards and Circulars,	£28 11 6		
Minute and Receipt Books,	1 8 6		
Rent, Insurance, and Attendance,	13 1 6		
Collector's Commission, Postages, and Petty Expenses,	4 8 6		
Carriage of Parcels,	3 13 10		
Disbursements by Secretaries,	7 4 0		
Subscription to Palæontographical Society,	1 1 0		
		59 8 10	
Bank Account—Lodged,		12 0 0	
Balance—Due by the Treasurer,		1 17 8	
			£165 2 0

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ABSTRACT OF TREASURER'S ACCOUNTS.—*Continued.*

STOCK ACCOUNT.

To Balance to Credit,			£523	17	8	
By Funds Invested—						
Loan to Corporation of Campbeltown,	£250	0	0			
Cash in Bank on Deposit Receipt,	12	0	0			
				£262	0	0
,, Cash in Treasurer's hands,				1	17	8
,, Books in the Library,				150	0	0
,, *Transactions* in Stock,				50	0	0
,, Furniture,				22	0	0
,, Fossils,				18	0	0
,, Microscope,				20	0	0
			£523	17	8	

NOTE.—The Expense of Part II., Vol. VII. of *Transactions*, forms a deduction from this sum.

LIFE SUBSCRIPTION ACCOUNT.

1884—Sept. 30.—To Balance to Credit,			£120	15	0	
1883—Oct. 1.—By Balance,				£115	10	0
Nov. 10.— ,, Mr. C. L. Dobbie,				5	5	0
			£120	15	0	

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Abstract of the Treasurer's Accounts for the Year ending 30th September, 1885.

CASH ACCOUNT.

RECEIPTS.

Balance—Due by the Treasurer at close of last Account,		£1	17 8
Annual Subscriptions—			
Arrears for 1883-84, ...	£2 10 0		
Subscriptions for current year, 153 at 10s.,	76 10 0		
Do., New Members, 15 at 10s., .	7 10 0		
		86	10 0
Interest on Invested Funds, ...		10	0 5
Publications Sold, ...		2	18 0
Bank Account—Drawn, ...		12	0 0
		£113	6 1

EXPENDITURE.

Transactions—			
Lithographing Plates for Part II., Volume VII.,		£17	12 0
Ordinary Expenditure—			
Rent, Insurance, and Attendance, .	£13 9 0		
Bookbinding, ...	9 8 8		
Distributing *Transactions*, etc., .	3 18 6		
Carriage of Parcels, ...	1 6 5		
Printing Cards, Circulars, and Receipt Book, ...	5 3 6		
Disbursements by Secretaries, . .	4 11 6		
Do. by Librarian, . .	0 7 4		
Collector's Commission, Postages, and Petty Expenses, . . .	4 10 9		
Subscription to Palæontographical Society, ...	1 1 0		
		43	16 8
Library, for New Books, ...		10	0 0
Bank Account—Lodged, ...		40	0 0
Balance—Due by Treasurer, ...		1	17 5
		£113	6 1

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ABSTRACT OF TREASURER'S ACCOUNTS.—*Continued.*

STOCK ACCOUNT.

To Printer's Account for Part II., Vol. VII., of *Transactions*,			£74	14	0	
,, Sundry Petty Debts,			12	0	0	
,, Balance to Credit,			475	3	5	
			£561	17	5	

By Funds Invested—					
Loan to Corporation of Campbeltown,	£250	0	0		
Cash in Bank on Deposit Receipt,	40	0	0		
				£290	0	0
,, Cash in Treasurer's hands,				1	17	5
,, Books in the Library,				160	0	0
,, *Transactions* in Stock,				50	0	0
,, Furniture,				22	0	0
,, Fossils,				18	0	0
,, Microscope,				20	0	0
				£561	17	5

LIFE SUBSCRIPTION ACCOUNT.

1885—Sept. 30.—To Balance to Credit,			£120	15	0	
			£120	15	0	

1884—Oct. 1.—By Balance,			£120	15	0
			£120	15	0

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OFFICE-BEARERS.

SESSION 1885-86.

President—SIR WILLIAM THOMSON, LL.D., F.R.S., &c.

Vice-Presidents.

MR. WILLIAM JOLLY, F.G.S. MR. D. C. GLEN, F.G.S.
MR. JOHN YOUNG, F.G.S.

Council.

Mr. D. FORSYTH, M.A., B.Sc.	Mr. JOHN M. CAMPBELL.
Mr. JOSEPH SOMMERVILLE.	Mr. JAMES ANDERSON.
Mr. CHARLES L. DOBBIE.	Mr. ARCHIBALD ROBERTSON.
Mr. JOHN FARQUHAR.	Mr. DANIEL M'MILLAN.
Mr. DUGALD BELL.	Mr. JAMES DAIRON, F.G.S.
Mr. WILLIAM ARMOUR.	Mr. MATTHEW BLAIR.

Hon. Treasurer—Mr. JOHN WIGHT, C.A., 150 Hope Street.

Hon. Librarian—Mr. JAMES WHITE, 56 Rose Street, Garnethill.

Hon. Secretary and Editor of *Transactions*—Mr. JAMES B. MURDOCH, Barclay, Langside.

Assistant Hon. Secretary—Mr. GAVIN M. PRATT, 104 West Graham Street.

Publishing Committee.

Mr. JOHN YOUNG.	Mr. DUGALD BELL.
Mr. D. C. GLEN.	Mr. GAVIN M. PRATT.
Mr. DAVID FORSYTH.	Mr. J. B. MURDOCH (*Convener*).

Library and Museum Committee.

Mr. C. L. DOBBIE.	Mr. JAMES ANDERSON.
Mr. WILLIAM ARMOUR.	Mr. JAMES DAIRON.
Mr. DAVID FORSYTH.	Mr. JAMES WHITE (*Convener*).

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY

OF GLASGOW.

VOL. VIII.—PART II.

1886-87, 1887-88.

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The Editor begs to state that the Authors are alone responsible for the facts and opinions contained in their respective papers. He has to apologize for some delay in the issue of this part, arising from the fact that several authors whose papers were to have been included have not sent them in.

JAMES BARCLAY MURDOCH, F.R.Ph.S.E.

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TRANSACTIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

No. XVIII.—On the Post-pliocene Beds of the Irvine Valley, Kilmaurs, and Dreghorn Districts. By Robert Craig, Langside, Beith, *Corresponding Member.*

[Read 13th January, 1887.]

Introduction. — On 12th January, 1882, Mr. John Young, F.G.S., and the writer, exhibited before this Society a fragment of a tusk of *Elephas primigenius*, Blum., and some shells, which had been found in sinking a pit on the farm of Drummuir, Dreghorn. These remains had been brought to our notice by Mr. Thomas Shore, at that time a clerk in the employment of Messrs. Merry & Cuninghame, the owners of the pit. In answer to a query, he stated that the shells, and "piece of wood," for which the tusk was at first mistaken, had been found in a bed of sand resting upon Carboniferous strata, and below 80 feet of Boulder-clay; but as regards the statement that the shell bed rested upon Carboniferous strata, this was afterwards discovered to be incorrect.

This find was an important one, Drummuir being nearly three miles south-west of the old quarry at Greenhill, where so many tusks of the Mammoth were discovered about sixty years ago, and I at once began to make further investigations. On proceeding to the place, I found that the discovery had been made in No. 5 pit, Drummuir, Warwickhill Colliery, belonging to the Glengarnock Iron Company, and I received from Mr. John Cuninghame, one of the partners, not only full permission to examine the pit, but also kind assistance by the loan of surface sections of numerous bores, which had been put down between Kilmarnock and Irvine,

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for comparison with pit sections put down in the same district. The manager, the late Mr. Walker, also gave me every facility and help in carrying out my investigations.

Section of the Pit No. 5, Drummuir.—The following section gives, in descending order, the beds cut through before the Carboniferous strata were reached :—

1st. Boulder-clay, 76 feet.
2nd. Stratified Sand and Clay, 2 feet.
3rd. Sand, about 4 feet, the Mammoth and Shell bed.
4th. Sands and Gravels, 20 feet.

The first of these beds is the Boulder-clay of the district, a hard stony clay, impervious to water, and of a light-brown colour, with a small percentage of carried rocks.

The second, Stratified Sand and Clay, is a series of very fine laminations of alternate layers of sand and clay, connected with the Boulder-clay. The clay layers at the bottom of this bed are of fine mud from $\frac{1}{16}$ to $\frac{1}{8}$ inch thick, the sand being 1 inch thick ; but this rapidly changes, the layers of clay getting thicker, and the sand thinner, so that in the height of 2 feet the sand has fallen into very thin laminæ, while the clay layers have thickened, imperceptibly running into Boulder-clay of the same character as that overlying this bed. This is no new feature in this district. The pit-sinker, Mr. Love, informed me that he had found this laminated sand and coarse clay, in a bed 6 feet thick in the bottom of the Boulder-clay ; and another sinker, Thomas Crawford, who has put down a number of the pits in this district, fully corroborated Love's statement. These stratified beds are not always present, but they have been found in a few of the pits. I found fragments of broken shells as high as the 2 feet, and I picked out a whole valve of *Astarte sulcata*, Da Costa, of large size, in sand about the middle of the bed.

The third bed of the section is the fossiliferous one, about 4 feet in thickness, though, as no sharp line divides it from the sand below, this depth is assumed, but shells are found throughout the whole 4 feet, if not some inches deeper. About a foot on the top is fuller of mud than it is below this line, and in the bottom of this muddy sand the Mammoth tusk was found.

The Sands and Gravels, the fourth bed of the section, form a series of unfossiliferous beds, 20 feet thick, and hold from top to bottom a small percentage of, apparently, West Highland rocks.

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The Mammoth and Shell Bed.—In sinking through the fossiliferous sand (the 3rd of the pit section) the sinkers came upon the tusk, lying diagonally across the shaft on a horizon agreeing with the bedding of the sand, but, mistaking it for a piece of fossil wood, they broke it up, and but for the curiosity of a joiner and another individual, it would never have been further heard of. One of the fragments, which came into my hands through the clerk, Mr. Thomas Shore, I sent to my friend, Mr. John Young, who at once discovered its value, and it was secured for the Hunterian Museum, along with some of the shells found with it. I was informed by Mr. Love, the pit-sinker who found it, that the total length of the tusk was about 5 feet, and its greatest diameter about 6 inches. He said that about 2 feet of the root or base end was in a state of decay, and fell into dust on being lifted. This was found to be correct, from the large quantity of dentine fibre discovered by washing parcels of the sand in which the tusk had been embedded.

This washing and examination of the sand was done by Mr. David Robertson, F.G.S., to whose kindness I am indebted for the list of fossils from No. 5 pit, Drummuir, given in the list appended to this paper. In the different parcels of sand sent to him Mr. Robertson found eight genera and ten species of Mollusca; twenty genera and thirty species of Foraminifera; and five genera and seven species of Ostracoda. There were also found by him fish scales, the elytra of a beetle, and the seeds of a plant. In two parcels taken from the group of Sands and Gravels, Mr. Robertson found five genera and eight species of Foraminifera, and a fragment of an Ostracod; but, as they are identical with those found in the fossiliferous bed, and as the sand was taken from the pit mouth shortly after a severe storm of wind, there is a probability that they may have been blown from the sand of the fossiliferous bed, which was lying close to the pit mouth, on to the end of the heap which had come from the Sands and Gravels. As, with this doubtful exception, this group of beds, the 4th of the No. 5 pit section, is unfossiliferous, I have not placed the shells found in it in the list.

The Mammoth and Shell bed, the 3rd of this section, differs from the section of No. 9 pit, Woodhill, as given by Mr. Young and the author in a paper read before this Society on 1st April, 1869, and printed in the *Transactions*, vol. iii., p. 310; and it also

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differs from the section of the stratified beds, or bed, beneath the Boulder-clay in the old quarry at Greenhill, described by Dr. James Bryce in a paper read before the Geological Society of London on 25th January, 1866, and published in the *Quarterly Journal*, vol. xxi., p. 213. In his section, Dr. Bryce makes an arbitrary division of the deposits found here beneath the Boulder-clay into three beds of distinct character, as follows :—

No. 2. Hard gravel; thickness, 2 feet; this rests on the Carboniferous strata.

„ 3. Fine blue clay, Mammoth bed; thickness, 9 inches.

„ 4. Sand, 6 to 18 inches.

The section given by Mr. Young and myself of No. 9 pit, Woodhill, already referred to, is almost exactly the same as that given by Dr. Bryce. It was furnished by Mr. Yates, jun., and was published by us in all confidence at the time. However, when the pit was worked out, and while filling it up, Mr. Yates, in accordance with a request which I made to him for further examination of the fossiliferous bed, took out the boarding from the shaft opposite this bed, and found it to be different from the published section. Unfortunately, after a few buckets-full of the sand had been removed, the side of the pit slipped in, stopping further examination, but enough was seen to prove that there was no intercalated "peaty bed," and that the sand was fossiliferous from top to bottom. The only thing approaching peaty matter was that the sand was darker in colour, and was muddier on the top of the bed as it neared the Boulder-clay. Thus, the section of No. 9 pit, Woodhill, proved to be very similar in character to the one in an air shaft, distant from it to the south-east 150 yards (not 250, as in our paper, by an overlooked typographical error).

Recent occurrences have also thrown doubts upon the arbitrary division of the Mammoth bed in the Greenhill old quarry into three beds of distinct character, as given by Dr. Bryce in his section. It appears that he had only one object in view in opening up the old quarry, which at that time had been closed for about twenty years, and that was to verify whether the tusks were found in true Boulder-clay, or in a bed of stratified clay. Roxbrough, the lessee of the new quarry there, had worked in the old quarry, and was the "aged quarryman" who, Dr. Bryce said, gave him the section, which agreed with the one furnished him by Mr. Turner, the Duke of Portland's factor. Roxbrough was also employed to

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re-open a pit in the old quarry, and it is strange that Dr. Bryce did not take a measurement of the re-opened section. That he did not he admitted in his paper to the Geological Society, according to the report in the *Geological Magazine*, vol. ii., p. 127, which says that "Dr. Bryce stated that the section had been sent by Mr. Turner." Mr. Turner, who is still living, corroborates this; and Roxbrough always said that Dr. Bryce did not take the section, as part of it had slipped in before he arrived. Yet Dr. Bryce speaks of having examined the sand bed, and that he found it thinned out eastward and westward. Roxbrough, no doubt, gave the section with the three distinct beds, and believed that he gave them correctly, although his memory was being influenced by the remembrance of conversations that he had heard. He was not in the quarry when any of the tusks were found, but he had heard from men who visited the quarry that the Mammoth was a land animal, and would be found on old land. This idea had got hold of all the quarrymen, pitsinkers, and others in the district, and the consequence was the invention of a "peaty bed" below the shell bed, in which the Mammoth remains were found.

The late discovery by Mr. Bennie, of the Geological Survey, of two bits of clay from the Elephant bed, Kilmaurs, is of high value. They had been sent to the Wernerian Society, along with part of a tusk, by Mr. Alexander Hood, surgeon, Kilmarnock, in 1817; and had been taken that year from the clay in the Greenhill quarry, in which the tusks were discovered. They had been properly labelled. They had been laid aside for nearly fifty years, when, fortunately, Mr. Bennie came across them with their labels entire, and examined them by washing. The result was given by him in a paper read before the Royal Physical Society of Edinburgh, on 20th of May, 1885, which was published in the *Proceedings* of the Society for that year, p. 451. From this paper I extract this and the following remarks which refer to it. In the examination of one of the pieces Mr. Bennie found one valve of *Astarte compressa* and a few valves of *Leda pygmæa*, with eight genera and nine species of Foraminifera, and five genera and ten species of Ostracoda. A number of seeds of plants and fragments of beetles were found in the other piece of clay, but no marine organisms were reported. This discovery is of great value, not only throwing light upon this celebrated bed, but in re-directing the attention of geologists to the report of the late Mr. Johnston of Redburn that

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marine shells were found in the clay in which the tusks were discovered, which had been lost sight of in consequence of the publication of Dr. Bryce's section.

Mr. Bald, in bringing the discovery of Mammoth tusks before the Wernerian Society (see *Memoirs*, vol. iv., p. 64), and apparently quoting from Mr. Johnston's report, states that the tusks were found in a clay of light brown colour, which had changed into a dark brown around the remains, with an offensive smell. "The tusks were found lying in a horizontal position with several small bones near them, and it is particularly to be remarked that several marine shells were found among the dark-coloured earth."

Mr. Bennie's discovery, coming as contributory evidence in support of Mr. Johnston's important remark, destroyed Dr. Bryce's arbitrary division of the stratified material beneath the Boulder-clay in the Greenhill old quarry into three beds of distinct character. This, when taken with the other sections of the bed, is sufficient to prove that marine shells are not confined to the sand said to rest upon the Mammoth clay bed, but that they also are found in this so-called clay bed itself. And if ever an opportunity presents itself for the examination of this section, I have not a doubt that shells will also be found in the run gravel below the clay, as was the case in No. 9 pit, Woodhill, as now ascertained.

In summing up the evidence, I have arrived at the following conclusions regarding the fossiliferous bed:—The shell bed in the two pits on Woodhill, and the Mammoth and Shell bed in the old quarry at Greenhill, and in No. 5 pit, Drummuir, are all parts of the same bed. There is a distinctively uniform character running through them that cannot be overlooked. Remains of a land fauna and flora, carried in by mechanical means, have been deposited in this bed of otherwise true marine character, and reached their greatest extent when the bed was about two-thirds deposited, in which position the Mammoth remains and the largest amount of plant remains were found. Marine shells, etc., being found mixed up with these prove that no cessation in the deposition of this marine bed had taken place. After this time an increased inflow of land organisms and an increase of mud have taken place, and have continued, until the bed was finally brought to a close by the advance of land ice and the deposition of the Boulder-clay.

This bed has been certainly found in four pits, and is reported

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to have been found in another (doubtfully) besides the old quarry on Greenhill. The fourth pit was No. 1, Finnie's Colliery, on the side of the Carmel, half a mile or so below Crosshouse ; and the other, which I regard as doubtful, was near (but a little to the north-west of) Crosshouse. Having been only found in these few places amidst a great many pits sunk around, it is evident that these are only patches of the bed preserved in hollows of the underlying sands and gravels.

Mr. Bennie, in his paper mentioned above, states that plant remains were only found in one of the pieces of clay, and, referring to the marine fossils found in the other, says "the one speaks of the sea and the other of the land." But this is rather obscure, as it is not plain whether he is speaking of this clay being from an old land surface, or only of the fossils coming from the land. Whatever the meaning, there is no evidence that any surface of old land exists either in this bed or in any of the sand and gravel beds lying beneath the Boulder-clay. Still, the presence of a land, or fresh-water, flora, and the remains of land animals, show that land was at no great distance.

Age and Position.—It is a curious fact that up to the publication of Dr. Bryce's paper geologists wrote as if the tusks of the Mammoth discovered at Greenhill were all found in the Boulder-clay, or Till. Mr. Bald, among the first to notice the discovery, thought that they were found in recent deposits above the Till. Dr. Scoular, who visited the quarry, and picked half a molar of the Mammoth from the removed clay, but neither perceived sand nor shells, stated that the material in which the tusks and half molar were found was the true Till, or Boulder-clay. This statement was accepted by geologists until Dr. Bryce, who had come to doubt its correctness, applied in 1864 to Mr. Turner, factor for the estate, to re-open a section of the old quarry, in which the tusks had been found, and so prove the correctness of Dr. Scoular's statement. This was accordingly done, but beyond satisfying himself that there was stratified material below the Boulder-clay, in which old quarrymen said the tusks were found, his work threw no new light upon the question. Finding that the tusks were found in strata beneath the Boulder-clay, Dr. Bryce put down the bed as the equivalent of the Cromer Forest-bed of Norfolk, and consequently pre-glacial. Mr. Young and myself, in the paper already quoted, after a close

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examination of the district and position of the beds in relation to the glacial clay, concluded that the Mammoth and Shell bed was pre-glacial. In 1872 the officers of the Geological Survey published an Explanatory *Memoir* to sheet 22 of the Survey, and in noticing the discoveries at Greenhill, state this bed to be inter-glacial. Dr. James Geikie, in his "Great Ice Age," accepts this view, and puts the bed down as inter-glacial; while in the already quoted paper by Mr. James Bennie he not only strongly upholds the same theory, but advocates its extension.

It may be difficult to find a term satisfactory for all parties, but after weighing all the available evidence, and reviewing the conclusions of the inter-glacialists regarding this bed, at least, the theory may be dismissed with the Scotch verdict of "not proven." If the inter-glacial position of this bed be founded upon the evidence given in the Survey *Memoir* already quoted, as it appears to be, then the evidence is defective. The *Memoir*, after noticing that some observers had compared the horizon of the bed to the well-known Forest bed of Cromer in Norfolk, says, "There are, however, no grounds for this inference." It continues, "An examination of the numerous bores and pit sections . . . in the Kilmaurs district shows that the Boulder-clay there contains interstratified beds of sand, gravel, and clay. Where the level of the surface of the solid rocks rises towards the surface of the ground, the intercalated strata of sand die off the slope until the rock comes to be covered directly by the overlying Boulder-clay. Where, on the other hand, the level of the rock sinks, as it does southwards and westwards, it passes beneath the horizon of the sand-beds, and a lower Boulder-clay makes its appearance under these beds. There can be no doubt that the strata containing the organic remains were formed during the deposition of the Boulder-clay which is found both beneath and above them," etc. It was, no doubt, beyond the scope of the *Memoir* to furnish details, yet, in a question of importance such as this, one or two sections might have been given where this lower Boulder-clay exists. If I understand the above rightly, the "sand, gravel, and clay" refers to the beds of sands and gravels which fill the valley of the Irvine beneath the Boulder-clay, and extend from near Shewalton to the village of Galston. Their breadth is very irregular, never more than one mile or so, with considerable gaps, and they run in depth from a mere nothing to nearly 40 feet. In no single pit that I have

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known, and I have been on the outlook now for a quarter of a century at least, has anything that could be called Boulder-clay ever been found beneath them, but they have always been found resting upon the Carboniferous strata. It is true that in a very few bores, the borers have registered in their journals, as existing in these sands and gravels, intercalated beds, as "gravel with clay," "gravel and clay," and "stony clay." Wherever these bores have been proved by pit, or open, sections, no material corresponding to Boulder-clay has been found. In a bore put down close to where No. 5 pit, Drummuir, was afterwards sunk, the borer had registered three kinds of Boulder-clay intercalated by beds of gravel, and 8½ feet of "gravel mixed with clay" beneath the sands and gravels, and resting on the Carboniferous strata. When the pit was afterwards sunk the Boulder-clay was found persistent in character throughout, and the 8½ feet under the sands and gravels was gravel of a clean and washed appearance, with no clay whatever mixed in it. In no pit, as already stated, have I known Boulder-clay, or clay of any kind, to have been met with, either beneath these sands and gravels, or intercalated with them. They, however, differ in character in different pits; in one they may be, and this is their general character, pure sand and gravel; in another they are nearly pure sand so indurated that a shaft can be sunk 6 feet without boarding; while in a third soft loose sand mixed with mud predominates. One thing the open sections prove, that bores not attended by experts are totally valueless in the settlement of delicate geological questions.

Conclusions.—Taking all this negative evidence into consideration, with the positive evidence now available, I see no cause to change the conclusions arrived at in our joint paper of 1869. Dr. Bryce's surmise that the fossiliferous bed may be the equivalent in age of the Cromer Forest-bed is, in my opinion, not far from being correct. I would even put these sands and gravels, with the fossiliferous sand bed, as of earlier age than this Forest bed, but it is impossible to correlate the glacial deposits of Scotland with those of England for any practicable purpose. From the first inflow of ice until its final disappearance deposition and destruction must have been at work. While deposition was active in one locality destruction would be as active in another where there was not water of sufficient depth to act as a preservative. Still there is a general character between these beds of the Irvine valley, and the

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beds in the Bure valley, near Norfolk. Both form a series of beds of sands and gravels, capped with a fossiliferous sand bed holding marine fossils. Both underlie the great mass of glacial deposits in their respective localities; and the shell *Tellina balthica*, Linn., makes its first appearance in English strata in the Bure valley beds, and its first appearance in Scottish strata in the Irvine valley. As this shell is found in all the higher fossiliferous glacial clays, and is still living in British waters, its presence is no proof of the age of this bed; still the coincidence is remarkable when the inferior position of both beds to the Boulder-clay of their respective localities is considered.

In thus putting this series of Sands and Gravels, with the Mammoth and Shell bed, at the very base of the glacial deposits, I admit that it supposes a submergence at the commencement of the glacial period, a subsidence not recognized by any Scottish geologist, so far as I remember. But the stratified layers of alternate sand and clay at the bottom of the Boulder-clay in the Drummuir pit is evidence of deep water, otherwise these laminated strata would have been destroyed by the ice that deposited the 76 feet bed of clay and stones which overlies them. The greater number of the Foraminifera found in the fossiliferous bed are still living, according to Mr. H. B. Brady, off the Shetland Islands, and to the north of them, in water of from 75 to 90 fathoms. A few are of brackish water habitat, but these might have been flooded in, as in all probability the tusks and land plants were. The increase of mud in the sand above the line of horizon on which the tusk was found in No. 5 pit, Drummuir, may indicate the approach of the ice. As it advanced, driving the land animals before it, many of them might be caught in a *cul-de-sac*, and perish of hunger, which would thus account for so many of their remains being found here.

It has been supposed by those who hold this bed to be interglacial that the group of Sands and Gravels beneath the fossiliferous bed is a re-wash from a lower Boulder-clay. But if this be so, where are the beds of fine clay which would be associated with the sands and gravels, and which are always so found in the re-washes that lie above the Boulder-clay? Their absence is a deathblow to the supposition; and as for the carried rocks, they may owe their present position to the carrying power of weeds attached to them, a power quite sufficient to account for the presence of the largest of them that I have yet seen.

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Note.—On 3rd March, 1872, I read a paper before this Society, "On the Glacial Deposits of North Ayrshire," etc., which was published in the *Transactions*, vol. iv., p. 138. It may be thought that the present paper is a recantation of the opinions I then advocated, but that is not so, and I still adhere to the general views set forth in that paper. But I wish to correct one error which I then committed in putting the Kilmaurs Mammoth bed on the top of the deposits of the lower glaciation, instead of placing it at the bottom of them, as I now do. When I placed the Mammoth bed at Greenhill between the two glaciations I was working on defective evidence, and had accepted this bed as a patch of the old land which I had found in the Beith district. The correction of that evidence by the re-examination of No. 9 pit, Woodhill, the new section in No. 5 pit, Drummuir, and the finding of marine fossils in what was supposed to be the land surface in the Greenhill quarry, all go to prove that the bed is marine, and that it lies at the bottom of the glacial deposits, or rather in the earlier stages of the glacial period. With this explanation I have now no farther alteration to make on my former paper, which, like all geological papers, must stand or fall by the evidence that may turn up hereafter.

On the following pages will be found a list of organisms from the Fossiliferous Bed beneath the Boulder-clay, referred to in this paper.

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LIST OF ORGANISMS FROM THE FOSSILIFEROUS BED BENEATH THE BOULDER-CLAY IN THE KILMAURS AND DREGHORN DISTRICT.

	Old Quarry, Greenhill.	No. 9 Pit, Woodhill.	Air Pit, Woodhill.	No. 5 Pit, Drummuir.
MAMMALIA.				
Elephas primigenius, Blum. (tusks).	x			x
Cervus tarandus, Linn. (horns).	x			
MOLLUSCA.				
CONCHIFERA.				
Cyprina Islandica, Linn.		x		x
Leda oblonga (*L. pernula*), Müller.		x		
,, *pygmæa*, Munst.	x		x	
Pecten Islandicus, Linn.		x		
Nucula tenuis, Mont.				x
Astarte compressa, Mont.	x	x	x	x
,, *sulcata*, Da Costa.		x		x
Tellina calcaria, Chemn.		x		
,, *balthica*, Linn.				x
Mya truncata, Linn.				x
GASTEROPODA.				
Littorina littorea, Linn.		x		x
Turritella terebra, Linn.				x
Natica Grœnlandica, Beck.		x		
,, *affinis*, Gmel.		x		
Fusus, sp. (?)				x
FORAMINIFERA (IMPERFORATA).				
MILIOLIDA.				
Biloculina elongata, D'Orb.				x
Miliolina seminulum, Linn.	x			
FORAMINIFERA (PERFORATA).				
LAGENIDA.				
Lagena globosa, Mont.				x

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	Old Quarry, Greenhill.	No. 9 Pit, Woodhill.	Air Pit, Woodhill.	No. 5 Pit, Drummuir.
LAGENIDA—*Continued.*				
Lagena marginata, W. and J.			x	x
,, *melo*, D'Orb.				x
,, *Williamsoni*, Alcock.			x	x
,, *sulcata*, W. and J.			x	x
,, ,, *var. lineata*, Will.				x
Glandulina lævigata, D'Orb.	x			x
Polymorphina lactea, D'Orb.	x			
,, *myristiformis*, Will.				x
,, sp. (?)				x
Uvigerina angulosa, Will.				x
GLOBIGERINIDA.				
Textularia sagittula, De Franc.				x
Bulimina aculeata, D'Orb.				x
,, *marginata*, D'Orb.				x
,, *pupoides*, D'Orb.				x
Cassidulina crassa, D'Orb.	x			x
Planorbulina Ungeriana, D'Orb.				x
Truncatulina lobatula, Walker.	x			
Rotalia Beccarii, Linn.	x			x
NUMMULINIDA.				
Nonionina depressula, W. and J.				x
,, *asterizans*, F. and J.				x
,, *orbicularis*, Brady.	x			
,, *scapha*, F. and M.	x			
Polystomella crispa, Linn.				x
,, *striato-punctata*, F. and M.	x		x	x
,, sp. (?)				x
CRUSTACEA.				
OSTRACODA.				
Cythere Dunelmensis, Norman.	x			
,, *concinna*, Jones.	x		x	
,, *limicola*, Norman.	x			x
,, *pellucida*, Baird.				x
,, *viridis*, Müller.	x			x
Cytheridea papillosa, Bosq. (young specimen).	x			x
,, *punctillata*, Brady.	x		x	x
,, *Sorbyana*, Jones.	x			

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	Old Quarry, Greenhill.	No. 9 Pit, Woodhill.	Air Pit, Woodhill.	No. 5 Pit, Drummuir.
OSTRACODA—*Continued.*				
Cytheropteron latissimum, Norman.	x			
Cytherura cellulosa, Norman.				x
Eucythere argus, Sars.				x
CIRRIPEDIA.				
Balanus porcatus, Da Costa.				x
PISCES.				
Fish scales (undetermined).				x
PLANTÆ (SEEDS).				
Potamogeton (allied to *P. rufescens*, Schard).	x		x	x
,, (allied to *P. Zizii*).	x			
,, (allied to *P. heterophyllus*).	x			
Ranunculus aquatilis.	x		x	
Myriophyllum spicatum, Linn.	x			
Carex, sp. (?)	x			
Potentilla, sp. (?)	x			
Chara, sp. (?)	x			
Isoëtes, sp. (?)	x			
INSECTA.				
Beetles (fragments).	x			x

NOTE.—I have much pleasure in stating that this list has been made up by the help of kind friends, whom I have to thank for their valuable aid. The entries in the first column, under Old Quarry, Greenhill, are taken, with Mr. Bennie's consent, from his paper, "On Two Bits of Clay from the Elephant Bed, Kilmaurs." (*Proc. Royal Phys. Soc.*, Edin., vol. viii. p. 451.) Those in the other three columns are the work of Mr. David Robertson, F.G.S., who kindly washed parcels of the sand from the pits, in which he discovered all the Microzoa, and the most of the shells recovered. The existence of seeds in the peaty clay was first demonstrated by Mr. John Young, F.G.S., who in 1869 washed a piece of clay which had been sent with the tusk of 1829 to the Hunterian Museum, finding in it "upwards of 300 seed-cases and seeds of plants, the most abundant being a species of *Potamogeton*, and one of *Ranunculus*, along with a few seeds of *Hippuris*." (See *Trans. Geol. Soc. of Glasgow*, iii., 314.) Mr. Bennie having, in 1884, recovered a bit of the peaty clay sent to Edinburgh with the tusk of 1817, followed Mr. Young's example and washed it, finding the seeds indicated in the first column of the text. (*Proc. Royal Phys. Soc.* Edin., viii., 451.)

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Chris. Meadows, Delt. Robertson Brothers, Collotype.

FOSSIL TREES, VICTORIA PARK, WHITEINCH.

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No. XIX.—Notes on a Section of Carboniferous Strata, containing Erect Stems of Fossil Trees and Beds of Intrusive Dolerite, in the old Whinstone Quarry, Victoria Park, Lower Balshagray, near Whiteinch and Partick. By John Young, F.G.S., and D. Corse Glen, F.G.S. With an Illustration. [Plate IV.]

[Read 12th April, 1888.]

On the north side of the Dumbarton Road, near Whiteinch and Partick, there is to be seen in the Lower Balshagray grounds a small ridge or knoll running east and west, crowned by a group of stately trees rising above the level tract of land, which here to the north bounds the river Clyde, its height above the present sea-level varying from 20 to 25 feet. The ridge is composed in its upper part of beds of intrusive dolerite, which are here seen to be intercalated with Carboniferous sandstones and shales, the igneous rock being traceable westwards for nearly two miles, when it again disappears under the overlying strata of the district. The knoll now lies within the area of ground rented by the burghs of Partick and Whiteinch as a public park, and is at its south-western extremity. In former years, a quarry had been opened in the upper bed of dolerite, the rock being used for macadamizing purposes on the neighbouring roads. Since it came into the hands of the Partick and Whiteinch Commissioners, a great deal of work has been expended in dressing up and planting the rocky slopes of the old quarry; and while employed last winter in cutting a road along the hollow of the quarry, the workmen exposed the strata in which a number of fossil trees were found to be embedded. These strata underlie the upper bed of dolerite now largely quarried away, and consist of gray sandy shales, flaggy sandstones, and dark carbonaceous shales, in the bottom of which the erect stems of the fossil trees are seen to be rooted. When the workmen came upon the upper end of the stems, the excavation was carefully continued downwards until both trunks and roots of five large trees were laid bare. Four of these stand close to each other, the fifth and largest being some distance apart at the western end of the excavation. It is very probable that other tree stems exist in the immediate proximity, as the sandstones and shales are found to be continuous on either side of the cutting for the roadway, those on the north

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side being seen to extend under the overlying dolerite which has here not been quarried away. Other five trees have recently been exposed standing near the others, besides two prostrate stems, which are seen lying across the section in the cutting.

The geological horizon of the group of strata in which these trees are found lies in the middle and lower divisions of the Possil coal and ironstone series, and which extends from this point eastward under the city boundaries, where it underlies the Millstone Grit and Upper Coal Measures, the beds in question being some 500 fathoms under the upper red sandstone which lies over the higher beds of the Lanarkshire coalfield.

The occurrence of erect stems of fossil trees, apparently on the same geological horizon as those above mentioned in the old quarry at Victoria Park, has been formerly recorded from several localities to the north-west of Glasgow. The most recent was the discovery in the Gilmourhill quarry, where six erect stems, standing close together, were exposed in the year 1868, during the working of the sandstone for the new buildings of the University. The strata in which they were found were identical in character with those seen in Victoria Park quarry. As a notice of the strata of the Gilmourhill quarry, and of the erect fossil trees found there, and at other localities within this district, formed the subject of a paper read to this society by one of the authors twenty years ago (*Transactions*, vol. iii., 1869), it is unnecessary to repeat what is there stated regarding either this group of strata, its geological horizon, or its fossils, beyond the following short quotation where mention is made of the trees:—"In the working of the upper bed of sandstone the quarrymen came upon the erect stumps of five or six large fossil trees. They appeared to be *Sigillaria*, and measured from 20 inches to 2 feet in diameter. They seem to have been broken, or to have decayed to within a few inches of the ground, and were composed of shaly sandstone, similar to the surrounding rock. The trees stood some three or four feet apart, and the roots of the one were seen in some cases interlacing with those of the others. While the remains of this old forest of the coal period were allowed to stand, they formed a very interesting object in the quarry, but they were ultimately removed in the working of the sandstone. Remains of large erect stumps of fossil trees from this neighbourhood are recorded in the

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writings of Dr. Buckland, Mr. Smith of Jordanhill, and Mr. John Craig, mineral surveyor. Dr. Buckland states, in his "Anniversary Address to the Geological Society of London," 1840, "At Balgray, three miles north of Glasgow, I saw in the year 1824, as there still may be seen (1840) an unequivocal example of the stumps of several stems of large trees, standing close together in their native place in a quarry of sandstone of the Coal formation." These trees have now all been removed, but their position was, we believe, nearly on the same geological horizon as the trees found in the sandstone of the Gilmourhill quarry. It is therefore interesting to find them scattered over a considerable tract of country.

What we shall now endeavour to notice further regarding the new discovery at Victoria Park will be some of the more local conditions that the section presents and the proofs it affords of the great antiquity of the strata. There is nothing abnormal, however, in this section as to the conditions under which the trees originally existed. They evidently formed a portion of one of those widely extended coal forests, which over this district flourished on this horizon in Lower Carboniferous times. In the strata underlying and overlying the beds containing the fossil trees we have clear evidence that this region was then one of gradual and slow depression, which probably extended over the whole area of our coal-fields, and also over much of the country beyond. There is also further evidence that this general depression continued until more than 3,000 feet of strata were deposited above the particular horizon in which these trees now lie. The evidence for this assertion, as to the great accumulation of strata, and the downward movement of the beds, is revealed by the nature of the strata themselves.

It is now generally admitted by geologists that all our beds of free, or cherry coal, whether thick or thin, were derived from growths of vegetation which flourished on the tracts of land where these coal-beds now exist. On the other hand, the strata of sandstone, limestone and shale, which alternate with these coal-beds, as clearly attest in their contained fossils what were the conditions, lacustrine or marine, under which their sediments were deposited. The coal-beds mark the periods of former land-surfaces, during which the underlying crust remained stationary, whilst the sedimentary strata mark the periods of depression when the land went down under water, either of lakes or of the sea.

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It may be interesting here to note the often-repeated occurrence of old land surfaces which exist, in the form of coal-beds, in the Possil group of strata lying between the horizon of the lower and upper marine limestones, near Glasgow. In the Gilmourhill quarry, already referred to, seven seams of coal were exposed in a thickness of 70 feet of strata. Mr. James Duncan of Twechar has sent us journals of bores put down through the same group of strata further to the east, in the Kelvin Valley, near Kilsyth, which show at least forty seams of coal, occupying horizons in the strata which lie under the upper, or Arden, limestone of the district; and over that, in descending series, of the Garibaldi ironstone, which is also worked in the Jordanhill and Knightswood pits, in the neighbourhood of Victoria Park, the distance, or thickness of strata, between the limestone and ironstone, being 207 fathoms, or 1,242 feet.

The seams of coal are generally thin, but several have been found of workable thickness within the district, such as the Shirva coal, which runs from 5 to 6 feet thick in the neighbourhood of Kirkintilloch and Kilsyth, and which is there worked, along with other of the thinner seams. The whole of these beds of coal indicate periods of repose, of longer or shorter duration, in which the land remained stationary, but they likewise mark as many periods of subsidence, when the land went down. When both are looked at and considered together they represent a very lengthened period of time, as the Possil group, which, it must be remembered, only forms the lower division of the 3,000 feet of coal measures formerly mentioned, once lay, we have every reason to believe, over the horizon of the trees now exposed in the quarry at Victoria Park. There is, however, a further period of time represented by the above section—the period required for the denudation of the whole of the coal measures which once lay over these beds in this district. Which of these periods was the longest, that represented by the slow growths of numerous coal seams and 3,000 feet or thereby of various intercalated sedimentary strata, or that during which the whole of this amount of strata has been removed by denudation, after the elevation of the region above the present sea-level? We are afraid that none of these points will ever be satisfactorily determined, as the period of deposition, and that of denudation, seem each so great as to lie almost beyond the grasp of the human mind.

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Of the ten trees which have now been exposed at Victoria Park only the lower portion of the stems and the roots nearest to them have been preserved. One of the stems is, as already mentioned, much larger than any of the other nine, and stands apart in the western end of the excavation. It is of an oval form, and measures across the stem, which has decayed to near the level of the roots, about 4 feet by 3 feet in diameter. The other trees, which have their stems preserved to heights of from 2 to 3 feet above the roots, have diameters varying from 20 inches to nearly 3 feet, about the same size as the Gilmourhill trees. They are seen to have been buried near their roots in a dark carbonaceous shale containing numerous fragments and impressions of plant remains. A more arenaceous shale of lighter colour surrounds the upper portion of the stems. It may be here noted that the heights to which the stems have been preserved were in all probability determined by the depth of sediment which had accumulated around their bases ere the trees themselves had decayed downwards to their present level. Above this level the strata in the quarry were found to be quite continuous over the upper ends of the stems.

The erect stems of some twelve or fourteen fossil trees belonging to the lower Carboniferous Period, which were discovered by Mr. E. A. Wünsch, F.G.S., in a coast section in the Island of Arran, where they had grown on two or three distinct horizons, had the lower portion of their stems entombed in beds of volcanic ash, which determined the heights to which they were afterwards preserved. In a paper by Mr. Wünsch, with a diagrammatic sketch showing the trees in position (*Transactions*, vol. ii., p. 98), he says: "The height of the trunks is limited by the thickness—about three feet—of the enveloping bed of ash, in which they seem to have been buried suddenly. At the same time numerous branches must have been broken off, and covered up by the ash around the stems of the trees." We are inclined to believe that the preservation of erect stems of trees in any strata in which they may be found, is always due to the material having been accumulated around their bases ere the trees themselves had decayed down to the levels at which their stems are now found standing. These stems, it must be remembered, generally existed as hollow moulds which only represented the external form and the surface markings on the trees, but not

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the wood itself; this having decayed in most instances ere their interiors became filled with the sandstone or shale, as the case may be, which now forms what are known as "casts" of the stems.

The external markings which exist on the casts of the stems of the trees under notice are somewhat obscure. They have been examined by Mr. Robert Kidston, F.G.S., Stirling, an authority on fossil plants whose opinion we are glad to have, and whose remarks on the subject will be found following this paper. Mr. Kidston informs us that he is inclined to regard the trees as belonging to the *Lepidodendron* family, rather than to that of *Sigillaria*. In this view he seems to be strongly supported by the abundance of fragments and impressions of stems of *Lepidodendron* which exist in the shale above the roots of the trees, and which he believes all belong to one species, *L. Veltheimianum*, Sternb., which is also found on many other horizons in the Scottish coalfield. In the shale are also found remains of stems, and various impressions of plants which have not yet been fully determined. From the way in which the intrusive dolerite is seen to have been injected among the strata in this locality, hardening, crushing, and burning the shale beds, many of the plant remains have been rendered more obscure than otherwise they might have been.

The only other traces of organic life which have yet been met with in the strata of the quarry, are the remains of Annelide burrows, which have been found in the surface layers of some of the flaggy sandstones. They belonged to a species of *Arenicola*, the tubes of which are very abundant in many of the sandstone beds lying within the Possil group of strata. For a notice of these and other organisms found in this group, we refer those interested to the list appended to the paper on the Gilmourhill quarry formerly mentioned.

The dolerite which is seen to be intrusive in the strata of the Victoria Park quarry presents the same mineralogical characters as that found intrusive in other horizons of the coal measures in the districts around Glasgow. It generally occurs in the form of extended sheets or bosses, and although seen to be intrusive in several distinct horizons of strata which range from the lower limestone series up into that of the higher coal measures, yet it is believed to have all been erupted about the same period of time, a period later, as has been clearly shown (at

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pp. 39 and 44 of *Memoirs* of the Geological Survey for sheets xxiii. and xxxi.), than the deposition of the Scottish Carboniferous strata, although probably older than the upper red sandstone that overlies the coal, and in which the dolerite has apparently not yet been found to be intrusive.

In its several exposures over the country this dolerite is seen to vary more in its crystalline characters than it does in its mineral composition. It is a truly basic rock, of a dark greenish-grey colour, which within the limits of the same quarry often varies from a coarsely crystalline into a fine grained and compact structure. Where thinner sheets and veins derived from the main mass are found to be intrusive in higher or lower levels of the strata in the same locality, as in the quarry at Victoria Park, the rock is generally seen to pass from its normal dark colour into different shades of light grey and greyish-white, the alteration being evidently due to its contact with the sedimentary rock, and to rapid cooling, especially along the lines of contact. In this quarry we have the interesting evidence that along these lines, especially in the thinner veins, the dolerite has cooled as a vitreous glassy lava, in which a thin layer showing micro-spherulitic structure has been developed during the process along the surface of both faces of the vein. These veins are now seen to have lost their glassy structure through devitrification, and are of a whitish colour, but their spherulitic structure, which still remains, clearly indicates that they once existed as veins of a glassy tachylite. This is the first instance in which we have found such a structure amongst the dolerites of the Glasgow coalfield.

The exposure of the dolerite here is evidently due to a fault which has brought it nearer to the surface, it having subsequently been laid bare by denudation of the overlying strata. Near where the trees have been found it dips, at a low angle to the north-east, under the higher remaining strata of the district. About twenty years ago it was bored through at a considerable depth underground, on the farm of South Balgray, in this district, but to the north it does not again show itself at the surface until we come to the neighbourhood of Milngavie, where its intrusive sheets are once more seen, but on a much lower horizon, amongst the sandstone strata which underlie the Campsie main limestone. At the Linn of Baldernock, a little further to the east, the dolerite is seen to be intrusive amongst the same limestones, forming the

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roof of one of the mines. Its subsequent intrusive character is often clearly displayed in many of the localities where it appears at the surface, as well as in those places where it has been met with in underground workings, the strata with which it comes in contact bearing evidence of having been strongly heated and otherwise altered, coal being converted into anthracite and coke, or sometimes burnt into a sooty condition, while sandstones are often much hardened and cracked, and shales are porcellanized into flinty conditions (see Geological Survey *Memoirs*). Such alterations in the strata, where these come in contact with the intrusive dolerite at Victoria Park old quarry, are clearly traceable at several places where the beds are exposed.

At one spot within the area of the excavation in which the erect stems of the trees are standing, one of the thinner horizontal veins of dolerite, in its extension through the shale, cuts right across one of the trees a little above the roots, and now forms a layer across the stem. Besides the geological interest attaching to this mode of occurrence of the dolerite, the fact also affords clear proof of its intrusion subsequent to the growth of the trees and the deposition of the shales and sandstones which afterwards surrounded them.

In the Geological Survey *Memoirs* explanatory of the several sheets which embrace the Western Scottish coal-field, and which, in the course of this paper, have been several times referred to, numerous interesting instances are given to show how these intrusive dolerites or basalts have altered and burned many of the coal strata with which they have come in contact, and also how the igneous rock itself has been altered from its normal conditions into that of the white decomposed varieties found in many districts.

In bringing our remarks on this interesting section and its fossil trees to a conclusion, we have only to add that we feel much more might be written upon the geological phenomena here displayed, as well as on the lessons which might be deduced. The nature of the strata in which the stems have been embedded forbids the idea of their being preserved for any great length of time, unless carefully protected from weather influences. Should their fate, however, be like that of the group of Gilmourhill trees, already mentioned, we shall at least have the satisfaction of recording, by the excellent and faithful drawing

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made for us by our friend Mr. Chris. Meadows, their present appearance, as well as their position and relation to each other, when seen standing on the ground on which they lived and died countless ages ago.

No. XX.—Note on the Nature of the Fossil Trees found at Whiteinch. By R. Kidston, F.R.S.E., F.G.S.

[Read 12th April, 1888.]

In view of a paper being read this evening by Mr. John Young, F.G.S., and Mr. D. C. Glen, F.G.S., on the section of Carboniferous strata containing erect stems of Fossil Trees and beds of intrusive dolerite, near Whiteinch, might I be allowed to correct a popular error, which has been widely circulated in the newspapers, in regard to the generic identification of these trees.

The fossil trees and their stigmarian roots lately discovered at Whiteinch have been usually referred to as *Sigillaria*, simply, I presume, from the stems and their surrounding matrix showing irregular longitudinal fissures. Such irregular fissuring of the trunk only occurs in the clathrate *Sigillaria*, and never on those with longitudinal ribs. The ribs on *Sigillaria*, when observable at all, are always regular, and do not suddenly cease and a new one spring up a little to the side of the first, run a short distance, and in turn cease. In addition, the furrows (they cannot be called ribs) on the Whiteinch examples are slightly flexuous or zigzag.

In the beginning of March I paid a visit to the Victoria Park, Whiteinch, and through the kindness of the curator, Mr. Duncan, had every facility given me for a careful examination of the fossils. All the trunks I saw had more the character of *Lepidodendron* than of *Sigillaria*, and even did they belong to *Sigillaria* it must be to the clathrate group.*

In certain *Lepidodendra* the bark, from pressure exerted on it from within by the ever increasing stem, splits longitudinally into irregular clefts, and in two *Sigillariæ* (*S. discophora*, König, sp., and *S. Taylori*, Carr.), this also occurs from a similar cause, but in the latter genus I have not seen it carried to the same extent. From any character shown by the stems themselves, as exhibited at

* Those with contiguous leaf-scars and no ribs, as *S. Brardii*, Brong.

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Whiteinch at the time of my visit, no sure generic determination could therefore be made with certainty.

There is, however, another way by which not only the genus, but also the species to which the Whiteinch fossils belong, can be ascertained, viz., by the fossils found in the shale surrounding the trunks. These, which were kindly shown to me by Mr. Duncan, comprised only two species—*Lepidodendron Veltheimianum*, Sternb., and *Stigmaria ficoides*, Sternb., sp.—the latter being in reality the root of the former. There cannot then be any doubt as to the trunks being those of *Lepidodendron Veltheimianum*, and not those of *Sigillaria*. However well such large trunks may be preserved, I suspect in almost no case would the leaf scars be preserved at the base of the stem, for in the course of nature they would become effaced by exfoliation and the natural fissuring of the bark.

There is in my collection a large number of specimens of *Lepidodendron Veltheimianum*, showing this species in different stages of growth, and two of these fissured specimens I have already described. (*Annals and Mag. Nat. Hist.*, vol. xvi., 1885, p. 166, specimens 8 and 9.)

Lepidodendron Veltheimianum is an extremely common species in the Carboniferous limestone series and the Calciferous sandstone series of Scotland.

Ribbed *Sigillariæ* are all but unknown in the Lower Carboniferous rocks of Great Britain, and, so far as I can remember, I have only seen a single specimen from rocks of this age.

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No. XXI.—On the Glacial Phenomena of Scotland, with reference to the Reports of the Boulder Committee of the Royal Society of Edinburgh. By Dugald Bell.

[Read 12th May, 1887.]

The Twelfth Volume of the *Proceedings of the Royal Society of Edinburgh*, which has lately been added to our Library, contains the "Tenth and Final Report of the Boulder Committee, with Appendix containing an Abstract of the information in the nine Annual Reports of the Committee, and a Summary of the principal points apparently established by the information so received." This bears to have been presented to the Society in July, 1884. The Committee was appointed in 1871, so that their labours extended over a period of thirteen years. The publication of this final *Report*, and of the Summary which it embodies, seems to furnish a favourable opportunity for reviewing the work of the Committee as a whole, and endeavouring to estimate and sum up the results.

These *Reports*, it is scarcely necessary to say, contain a great mass of interesting information regarding boulders and their distribution in all parts of our country; information which has never before been presented in so complete and authentic a form, and which cannot be overlooked by any future student of the subject. In collecting it, the Committee have certainly rendered an important service to Geological science. Special acknowledgments are due to the Convener, Dr. Milne-Home, for the energy and enthusiasm with which he threw himself into the work. As has been said elsewhere—"At a time of life and after services which might entitle him to leave such observations to younger men, he has gone over the greater part of Scotland, visiting every remarkable boulder he could hear of, measuring, sketching it, noting its position, and otherwise putting it on record." ("Among the Rocks round Glasgow," p. 162.) We repeat this tribute all the more readily that we shall have occasion to differ widely from Dr. Milne-Home with regard to the interpretation of many of the facts recorded, and with regard to his general theory of the glaciation of our country—a difference which we hope always to express in a manner consistent with the respect due to him as a gentleman of high reputation and a veteran promoter of the science.

One does not go far in these *Reports* without discovering that

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the Convener is an out-and-out advocate of the "iceberg hypothesis;" glaciers or land ice he introduces as little as possible, apparently regarding bergs or floating ice as able to account for almost everything that is required. All the phenomena under notice he thinks may have been produced by icebergs carried by ocean currents from the north-west, and drifting over the country at a time when it was submerged to a depth of about 2,000 feet beneath its present level.

This theory he seems to have been led to adopt from his observations in the eastern and south-eastern parts of Scotland. Finding that it accounted fairly well, on a general view, for the facts observed in these districts, and also that it seemed to be consistent with those observed in the north-eastern counties of Elgin and Nairn, and parts of Ross-shire, he apparently came to the conclusion that it was universally applicable in Scotland, and did not see the difficulties, or rather, we should say, the insuperable objections, which attend it when viewed in relation to other parts of the country.

Thus we read in the 2nd *Report*—"On the mainland of Scotland, at least in its eastern half, the boulders appear to have come over a wide extent of country in one and the same direction, viz., from the north-west. This inference had been drawn years ago from such facts as the finding of granite and mica-schist boulders in the counties of Fife, East Lothian, and Berwick, which must have come from the Scottish Highlands. But further and more striking proofs of this great north-west movement are afforded by the large boulders in the counties of Elgin, Nairn, and Ross-shire," which, it is concluded, "must have been transported from mountains far to the north-west." (Vol. viii. p. 143.)* This, however, is by no means certain, as we learn afterwards they may have come from the sides of the Great Glen, in a direction from W.S.W. to E.N.E.

We need only select a few of the instances given:—

In Ayton Parish, Berwickshire, a boulder of same rock as Cockburn Law, 10 miles to W.N.W. Also, pieces of coal found in a bed of sand. Nearest place where coal strata occur is in Mid-Lothian, 30 miles to N.W.

In Coldingham Parish, rounded masses of hematite, from East

* The references throughout are to the volumes of the *Proceedings of the Royal Society of Edinburgh.*

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Lothian, 30 miles to N.W. At Blackadder, a boulder of blue whin, from Hardens, 5 miles to N.W. In Hutton Parish, blocks of a peculiar greywacke, from near Cockburn Law, 14 miles to N.W.

In the Parish of Dunse, a number of boulders, all carried in the same general direction from N.W.; among them porphyries from hills 3 to 6 miles distant, mingled with pieces of sandstone from the immediate neighbourhood to the west.

At Linton, East Lothian, a greenstone boulder from the Garlton Hills, 6 miles W. by N.

On Craiglockhart Hill, near Edinburgh, boulders of various kinds from N.W.—some of sandstone from a distance of only about a mile. At Alnwick Hill, near Liberton, in excavations for water-works, a great variety of boulders from W. and N.W.; some of red sandstone, such as occurs at Grange and Merchiston, others of marine limestone, similar to that in Linlithgowshire, others of quartz, etc., which probably came from the Silurian rocks near Callander. Boulders of mica-schist, doubtless from the last-named locality, also occur on the Pentlands.

Near Kirkliston, Linlithgowshire, a boulder of Old Red conglomerate, probably from the neighbourhood of Callander or Doune, N.W.

Further west, a considerable number of conglomerate boulders are found near Dunmore, Plean, Stirling, Bridge-of-Allan, and Doune, which, the Convener remarks, "are interesting, as the position of the parent rock is known, viz., that band of conglomerate which traverses the country at Callander." (See, *e.g.*, 4th and 5th *Reports*, vol. ix. pp. 677-683, and vol. x. pp. 591-605.) And so the conclusion is confirmed—"General movement from the north-west."

Of course those who hold the theory of a great development of glaciers or land ice as more consistent with the facts point out that all these instances, on which Dr. Milne-Home founds so much, occur on the *eastern side* of the principal mountain chains, from which it can be shown that the boulders and striæ radiated in *all* directions—N., N.W., W., S.W., and S., as well as E. or S.E. Whenever we come to the *western* side of these mountains, the marks of glaciation are in a different direction, indicating a movement on that side *westward* out to sea. On this point, we think a single day's excursion by Loch Earn or Loch Tay, up the valley of the Dochart to the neighbourhood of the Black Mount,

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and then down Glen Etive or Glencoe on the other side, is sufficient to convince anyone who fairly observes the facts.

Similar facts are presented very clearly in the south of Scotland—a district too little noticed in connection with glacial phenomena. The high grounds of Carrick and Kirkcudbright have evidently formed a centre of dispersion, from which the striations and boulders can be traced extending outwards on every side—to the N. and W., as well as to the S. and E. This, of course, is quite inconsistent with the theory of an ocean-current and floating ice or bergs.

If there had been a general inflowing current, laden with ice and boulders, from N.W., its traces should be most distinct and abundant on the west coast, which was first exposed to its impact. But it is precisely there that the evidences of ice-movement in a different direction are most conspicuous and unmistakable. It is on this western side of the country that the difficulties in regard to the theory favoured in these *Reports* thicken and accumulate.

Thus—(1) In the neighbourhood of *Loch Glashan*, near Loch Fyne, the Convener writes—"I was rather surprised to see the hills which sloped down to N.E. well covered with boulders, and also striated rocks facing N.E. and N.N.E." Again, near *Port Sonachan*, on Loch Awe—"I was rather surprised to find the boulders in such positions as to indicate that they had come from N.N.E. . . The rocks presented smoothings which faced N.N.E. . . I felt surprised at this direction as, when last year in the Hebrides and the west coast of Argyleshire, I had been accustomed to see that N.W. was the usual direction both of boulder transport and of rock striations." (6th *Report*, vol. x.) This observation, it is right to state with all respect, is not concurred in generally by geologists.

It had been stated in a previous *Report* * that "when boulders are on hills, they evidently indicate a preference for the sides of those hills having a N.W. aspect—a fact which seems to indicate the existence and prevalence of some transporting agent which could be more frequently and effectively stopped by the sides of hills facing N.W." (2nd *Report*, vol. viii.) But here are some stubborn and intractable boulders "indicating a preference" for a different side of the hill altogether! There was no help for it but

* Although it is apparent that the Convener did a great part of the work of drawing up the *Reports*, we wish to adopt, as far as possible, an impersonal style of remark by referring simply to "the *Reports*."

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to admit that "this N.N.E. direction of transport [*i.e. from* N.N.E.] appears to characterize all the boulders and the rock striations at the Gareloch, Loch Gair, and Loch Awe," evidently including Loch Long, Loch Fyne, and Loch Etive, and to suggest that "in this district there may have been a current of floating ice moving in a S.S.W. direction." Also, "that when the Highlands of Scotland were covered by the sea up to a height of, say, 2,000 feet, and when they presented an archipelago of islands, there may have been currents moving in different directions, and these directions changing as the sea fell from one level to another." (6th *Report*, vol. x.)

What is this but giving up entirely the "general movement from the N.W.," and virtually saying there is no order or certainty in the matter? But we shall refer to these "abnormal currents" further on.

(2) In noticing the *Crinan* district, which seems to us in itself decisive of the whole question of sea or land ice, the *Report* affirms that "there is nothing to suggest the action of a glacier," and adheres to the view that the phenomena in question were the work of sea and "floating ice." And Mr. Jamieson is referred to as having "stated in one of his papers in the *London Geological Society's Journal*, that he found "smoothed rocks on the east side of this valley, and striations running N.W. and S.E." The Reporter admits he "did not see these markings;" but he adds, "they are not inconsistent with the theory above suggested as to the transport of the boulders." (7th *Report*, vol. xi.)

This reference to Mr. Jamieson's paper ("On the Ice-Worn Rocks of Scotland," *Quar. Jour. Geol. Soc.*, vol. xviii. 1862), which is well known as one of the standard papers on the subject, is exceedingly inaccurate, and can only be accounted for by supposing that it was written from memory, under an erroneous impression, and without taking time to verify it. Mr. Jamieson distinctly states that the rocks of this district, presenting "some of the most beautiful examples of glaciation" he had ever seen, are marked with "long rectilinear grooves running uninterruptedly onwards *from N.E. to S.W.* for many yards, with all lesser degrees of scratching and polish." The ridges, he says, present invariably their rounded snouts to N.E., and their more rugged outlines to S.W.; and there is "evidence that the agent which impressed these furrows moved obliquely *uphill*, mounting a slope of 700 or

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800 feet." In short, he finds "the glaciation of the rocks of Knapdale looks as if the stream of ice descending Upper Loch Fyne (so great had been its volume, and so immense the *vis à tergo* impelling it onwards) had gone right out, over hill and dale, into the Sound of Jura." And, in his view, nothing short of ice "filling the valleys up to the brim, and covering the whole country in one great winding-sheet, will meet the requirements of the case." All this notwithstanding, when the Reporter visits Loch Swin, on the western side of Knapdale, he still thinks that the striæ and boulders indicate a movement inwards from N.W. (7th *Report*, vol. xi.)

(3) Coming to *Oban* and its neighbourhood, we find the clearest evidence that the channel of Loch Etive was once filled by a great mass of land ice moving westward out to sea. The *Report* admits that the rocky knolls along Loch Etive are all smoothed from the east, "indicating apparently the action of a glacier which had moved down the valley now occupied by the loch." (7th *Report*, vol. xi.) It is to be borne in mind that the whole of the upper part of this valley, from Bonawe to the head of Glen Etive, is formed of granite of several varieties, grey and reddish. It is perfectly certain that the glacier which once occupied the valley must have borne thousands of granite boulders, and deposited them in various positions near its termination and along its sides. Yet, in discussing the origin of such boulders around Oban, this seems not to be taken into consideration at all, but attention is constantly turned away to N. and N.W.

For example, the boulders in the little valley on the south side of Oban Bay probably came "from some north-westerly point." (7th *Report*, vol. xi.) The large granite boulder at the north end of the bay, known as the "Dunolly boulder," has a position close to the cliff, which raises a presumption that it came from W. or N.W. (4th *Report*, vol. ix.) Boulders on north end of Kerrera "probably came from same quarter." (*Ib.*) Boulders in the Pass of Brander are probably from the north, or "floated by ice flowing from N.N.W." (*Ib.*) A large granite boulder on the hills between Oban and Connal Ferry suggests a look towards Ben Cruachan on the east; but "there seems to be nothing improbable in the supposition that it may have been brought by floating ice from the north." (7th *Report*, vol. xi.) At Lailt, about 6½ miles from Oban, there is a perched boulder of considerable size. Judging from its

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position, "the presumption is that it came from S.E., *i.e.* down the valley leading up to Loch Awe. *But it may have come from the N.W.*, as in that direction there is a valley by which it could have floated to its present position." (5th *Report*, vol. x.) Near it are fragments of another boulder, whose position also "suggested transport from S. or S.W. [S.E. ?], though the N.W. was not impossible." (*Ib.* p. 154.) Instead of carefully observing the facts of nature, and impartially recording what they seem to teach, does not this look like trying to bend these facts into conformity with a preconceived notion or theory ?

(4) We pass on to what is said regarding the *Great Glen*, or line of the Caledonian Canal. The facts collected regarding the transport of boulders at the northern or Inverness end of it—in the work of collecting which our esteemed vice-president, Mr. Jolly, had a large share—leave no doubt that the general direction of movement in that quarter was from S.W. to N.E., *up* the line of the Great Glen, and out to sea by Forres and Elgin. Of course this is different from the standard normal direction—according to these *Reports*—from N.W. It is admitted that "the boulders whose parent rocks are situated on the hills forming the sides of the Great Glen have moved, not E.S.E. (the normal direction), but E.N.E." Some modification of the theory must, therefore, be made to meet these facts. "There can be no doubt," it is added, "that when the sea stood at a height of, say, 2,000 feet above the present level, and with a general oceanic current from W.N.W., the current in *Glen-na-Albin* itself—*i.e.* between the walls of the valley—would be in the line of that valley, forming a deep fissure across the country running about N.E., and that the force of this abnormal current would be sufficient to carry boulders transported through it in a north-easterly direction till it united with the more general stream from W.N.W." (5th *Report*, vol. x.)

Thus, the number of "abnormal currents" increases ; one from N.E. to S.W. in the district embraced by Loch Long, Loch Fyne, and Loch Awe, and another from S.W. to N.E. through the Great Glen. It may be questioned indeed whether, if the line of the Great Glen caused any change in the direction of the "general oceanic current from N.W.," it was not far more likely to be from N.E. to S.W.—always towards the warmer latitude—than in the reverse direction, turning back to the colder conditions of N.E.. Apart from this, we may note that the latter supposed "abnormal

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current" is quite inconsistent with the northern and north-western origin, which these *Reports* so resolutely insist upon with regard to the boulders on Kerrera and elsewhere around Oban; for how could boulders reach that neighbourhood from N. or N.W. across a powerful current—"sufficient to carry boulders, etc."—sweeping past it from the S.W.? It is also contradicted by the fact that in the southern half of the Great Glen the direction of boulder transport has been clearly to S. and S.W.* In fact, this change in the direction of transport along the line of the Great Glen—to N.E. at one end of it and S.W. at the other—is one of the leading facts subversive of the ocean current theory; for, of course, no such diverging ocean currents could originate in the centre of the glen.

"My idea is," we read in the 5th *Report* (vol. x.) "that whilst in the *higher* parts of the country the general traces of a W.N.W. current are everywhere distinct, in *low-lying* valleys the direction of the current would change in correspondence with the axis of these valleys."

May we venture to ask, how could this be? The supposed general oceanic current from N.W. (or "W.N.W.") would sweep across the country by all the cols or passes that were submerged, the higher ones allowing a less, and the lower ones a greater depth and volume of it to pass through them. When by the gradual elevation of the land, the higher ones got above water, the current at these points would simply cease; there could be no current where there was no continuous passage across; these valleys, so far as they continued to be submerged, would then become bays or inlets of "still water;" another current there, with a different direction, was impossible. Moreover, the "low-lying valleys," which would be longest under water and most continuously subjected to this wide-spread N.W. current, should be the most unlikely places to indicate currents in other directions; there, the traces of the general or prevailing ocean current should be most distinct, persistent, and uniform.

But we may note in passing, that, on the theory of the great deep-enveloping sheet of land ice pressing out on all sides from the high lands of the country, these changes of direction become quite intel-

* See Mr. C. Livingstone's "Notes on Boulders to West of Fort-William" (8th *Report*, vol. xi.), in which he shows that some of these boulders have come from the upper part of Glen Nevis, and others he believes were brought down the Great Glen from the neighbourhood of Glen Spean, etc.

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ligible. During its maximum, or period of greatest prevalence, this ice-sheet would maintain a uniform course over obstacles, which, as it shrank, would suffice to turn it aside. At length, when it existed as a number of separate local glaciers, these would "correspond with the axis of the valleys" in which they moved—east, west, north, or south, as the case might be, which cannot be imagined of oceanic currents.

Again, though at the time of greatest submergence the current might flow across the higher cols and passes of the country, its main draught and volume would be across the more open low-lying valleys; and this would undoubtedly determine the course of the icebergs. An iceberg differs so little in specific gravity from water that it has a very great proportional draught—seven parts of its bulk being under water to one above it. Its course, therefore, is determined not so much by winds, or eddies, or side currents, as by the main, deep, arterial oceanic currents. In these it sits, and to these it clings. It is extremely unlikely, therefore, that, even during the time of greatest submergence, icebergs would find their way into little side-valleys or land-locked inlets, where the water could only have escaped by a high and narrow neck or pass, and where, consequently, the draught must have been quite inconsiderable; they must have been mainly restricted to the broad open channels and sounds of the country. Yet it is precisely in these narrow valleys and land-locked inlets, and on the steep slopes of high mountains—in situations the most difficult to imagine that icebergs could ever have reached—that their supposed relics and evidences, in the shape of boulders, are most abundant!

But, not to dwell longer on such points, we submit further that —as appears to us—this theory of floating ice or icebergs, laden with fragments of rock, and borne across the submerged land by a general oceanic current from N.W., *will not account for the facts* which these *Reports* have recorded.

(*a*) With regard to the boulders themselves, looking only at those of the central valley in the meantime, the principal fact, of which an immense number of instances are given, is that boulders, more or less worn and rounded, from the mountains in the west are strewn over the country to the east; and these far-travelled boulders are mixed with pieces of local rocks—*i.e.* from nearer sources, but still from localities to the west. It is needless to repeat instances, we refer to those already given at p. 238-9.

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We know that similar facts are common in our own neighbourhood—boulders of the same kind of rocks as the mountains to N. and W. being mixed up plentifully with fragments of rocks from the immediate neighbourhood, sandstone, trap, shale, limestone, ironstone, in varying proportions, according to the locality.

Now, our contention is that the theory of a berg-laden ocean-current from N.W. will not account for these facts; and is, indeed, directly at variance with them. Let us consider the matter for a little. An iceberg is a portion of a glacier or sheet of land-ice which has broken off and floated away after the glacier or ice-sheet reached the sea. All the pieces of rock, large or small, which it bears on its surface, or more deeply embedded in its mass, fell upon it, or were enclosed by it, and borne away during its slow and gradual progress over the land. From the moment it reaches the sea, it gains nothing more, adds no more to its rocky burdens; on the contrary, it immediately begins to lose, dropping these burdens over the sea-bottom at less or greater distances from their parent beds. Itself in a state of gradual dissolution, its freight also is always becoming smaller and smaller. It is more than likely that it loses the greater part of the rocky fragments attached to it, or embedded in it, at an early stage of its progress; those fixed in its under surface, as it melts away, soon drop off; those on the top also speedily slide off and disappear; so that nearly all the icebergs that are recorded to have been seen at sea, have been remarkable for the absence of rocky fragments of any kind. Indeed, there can be little doubt that the ice-sheet parts with a large portion of its stony freight *before* any part of it breaks off to form a berg; as it protrudes from the land out to sea, it must be constantly dropping the pebbles and boulders with which it is charged. (See Geikie's "Text-Book.") So long as it floats, it is plain that the iceberg cannot pick up any fresh fragments of rock; what reason is there for supposing it can do so when it touches the ground? When it grounds on the sea-bottom, on a bank or some sloping ridge of submerged land, is it conceivable that it can, so to speak, recoup its losses by laying hold of and carrying away masses of rock from the land on which it has touched? It is surely unnecessary to point out that ice as it exists in an iceberg is hard and brittle, not a yielding or plastic mass into which substances can be dinted by pressure, and to which they may thus be made to adhere

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for a time. The shock of its stranding on the ground would tend to shatter it more or less, and to loosen from it any stones it was carrying, also to shatter any stones on which it struck; but could not, in the least appreciable degree, enable it to pick up or attach fragments of rock to itself, far less so to incorporate them into its mass that it could carry them onwards to spots many miles distant from where it came into contact with them. The idea of icebergs thus acting as accommodating carriers and deliverers, not only laying down but taking up anew as they go along, really seems, the more we think of it, to be a wonderful hallucination. We may accept it as perfectly certain that, whatever icebergs may drop or leave behind them in their progress, they can take up nothing by the way; their "bill of lading," so to speak, was made up and closed before their voyage began.

Accordingly, if these icebergs, which are supposed to have produced the effects under consideration, took their rise, as is alleged, in some distant tract of land to N.W., from which even the boulders on the West Coast of Scotland and on the Hebrides have been derived, it follows that none of these boulders found on the eastern parts of the country can really have been brought from the neighbourhood of Linlithgow, Doune, Callander, Kilpatrick, Inveraray, or Bonawe, as has been imagined; they must all have come from that distant tract where the ice was formed. Their resemblance to the rocks around Callander, Kilpatrick, Inveraray, etc., is a mere coincidence; there is not the least likelihood that (*by such means*) they ever came from these points. Their occurrence, also, in a certain definite order in relation to these rocks of the country is purely accidental; and it must be allowed to be wonderful that icebergs should have dropped fragments of rocks in a distinct order and succession, in a certain uniform position always, with regard to the rocks existing away down in the sea-bottom over which they were being carried!

We may confidently affirm, then, that this feature of the boulders—the mingling of nearer and more distant kinds which characterizes them—could never have been produced by icebergs. And this conclusion would be very much strengthened by a reference to the Boulder-clay, and its changes in colour and composition from point to point, in conformity with the subjacent rocks, but on this we do not at present enlarge.

(*b*) Further, not only the nature of the boulders and their rela-

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tion to neighbouring rocks, but also the *positions* in which they are found, are directly opposed to this iceberg hypothesis. These *Reports* frequently call attention to the fact, which is worthy of very close attention and consideration, that "another common feature presented by boulders is that when they are longer than they are broad, the longer axis is parallel with the direction in which the boulder had been transported. Very frequently, also, when one end is sharp and the other end broad, the former points towards the direction from which the boulder has come." (4th *Report*, vol. ix., p. 705.)

This last particular, however, as we shall see, is very open to question.

All through these nine *Reports*, the boulders are described with reference to these characteristics—"striæ parallel to longer axis," and "sharpest end pointing" in such a direction. This fact regarding the position of boulders—so far at least as regards the correspondence of their longer axis with the direction in which they had been moved—may be taken as very generally established. But, accepting the fact, we entirely differ from these *Reports* in the conclusion drawn from it. "On the theory of icebergs or floating ice," it is said, "this feature is intelligible; on any glacier or ice-sheet theory it is not." (4th *Report*, vol. ix., p. 705.) We should say exactly the reverse; on the glacier or ice-sheet theory it is intelligible; on any theory of icebergs or floating ice it is not.

Can any one show that it is in the least degree likely that the stones dropped from, or left stranded by, icebergs, would correspond in the position of their longer axis with the direction in which the bergs were going? Manifestly, the stones would be dropped or left stranded in *all* positions; and it would be by the merest chance if one in a hundred corresponded with the direction of the berg's course. The berg itself may have changed its shape, its longer axis, even the side on which it floats, more than once during its voyage. What shadow of a probability is there that the stones it may deposit will have any uniformity of direction? None whatever.

This is so obvious that we begin to think the theory maintained in these *Reports* must be that the position of the boulders, as regards their longer axis, etc., is due to the subsequent action of the ocean currents. In the 2nd *Report* we read—"It was a remark of Hugh

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Miller's that, on examining pebbles lying in the channel of a river, the great majority have their narrow ends pointing up stream. When once in that position, they retain the position longer than when lying broadside against the stream." (Vol. viii., p. 139.) Now, evidently this observation proves nothing with regard to boulders deposited by icebergs. The position of pebbles in a stream has really nothing to do with the matter—unless it be implied that these ice-borne boulders, many of them hundreds of tons in weight, and poised in precarious situations, had a certain uniform position imparted to them afterwards by the currents of the sea! This, we think, might be dismissed without further comment. But, first, we have grave doubts as to the accuracy of this observation, even though it be attributed to Hugh Miller. Masses of rock *in situ*, or that the stream could not move at all, may have their up-stream faces rounded or narrowed to some extent by the action of the current and the abrasion of sand and gravel, but that stones whose position *has been* affected by the current, could be arranged with their narrower and lighter ends pointing up-stream, seems impossible. We appeal to observation. In any movable body in a stream, if both ends be alike, will it not be rolled over and over, and if one end be sharper and lighter than the other, will not that end be wheeled round and point down stream? Then, secondly, we believe there is a mistake in the citation of the above passage. The reference is not given, and though we used to know Hugh Miller's writings tolerably well, we fail to remember in what part of them it occurs. We can, however, cite a passage from Hugh Miller of quite a different purport, and leave the reader to judge of the soundness of the reasoning, and its applicability to the point in hand.

In his well-known "Sketch-Book of Popular Geology," Miller refers to the fact of the pebbles and boulders of the Boulder-clay being scratched and grooved in the line of their longer axis, and argues that "the agent which produced such effects could not have been simply water, whether impelled by currents or in waves," for the smaller stones must have been *fastened* before they could have been scratched. "Even," he continues, "if the force of water could have scratched and furrowed them, it would not have scratched and furrowed them longitudinally, but across. Stones when carried adown a stream by the torrent, or propelled upward along a beach by the waves, present always their broader and

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longer surfaces; and the broader and longer these surfaces are, the further are the stones propelled. They are not *launched* forwards, as a sailor would say, *end on*, but *tumbled* forwards *broadside*. They come rolling down a river in flood, or upwards on the shore in a time of tempest, as a hogshead rolls down a declivity. In the boulder-clay, on the contrary, most of the pebbles that bear the mark of their transport at all were not *rolled*, but *slidden* forward in the line of their longer axis. They were launched, as ships are launched, in the line of least resistance, or as an arrow or javelin is sent on its course through the air. Water could not have been the agent here, nor yet an eruption of mud propelled along the surface by some wave of translation." (Pp. 31-2.)

So far Hugh Miller had got fully thirty years ago. This passage proves that in his opinion water, "whether impelled by currents or in waves," could not arrange these stones or boulders longitudinally, or give them those markings which show that they retained their longitudinal position even when rubbed and pressed against obstacles which they encountered in their way.

This very general uniformity, then, between the longer axis of the boulders and the directions in which these boulders have come —accepting it as a fact—we find (1) is quite inconsistent with the theory of the boulders having been dropped by icebergs; and (2) could not have been imparted to them afterwards by ocean currents.

Accordingly, all the instances of uniformity or coincidence in this respect which have been brought together in these *Reports*, tell powerfully against the theory which these Reports adopt and defend. The same remark applies to the almost universal striation of the boulders in the line of their longer axis.

So also in regard to the instances which have been adduced of boulders having their "narrow ends" pointing backward in the direction *from* which they have come; we are convinced that in at least some of these cases there has been—quite unintentionally of course—a mistake in recording the fact. So far as our own observation goes, nearly all the larger boulders, and those whose position we may suppose to be unaltered since they were laid down, have their narrow ends pointing forward in the direction *towards* which they were being transported. This is plainly, as Hugh Miller said, "the line of least resistance." We might instance the Inverbeg boulder on the western side of Loch Lomond,

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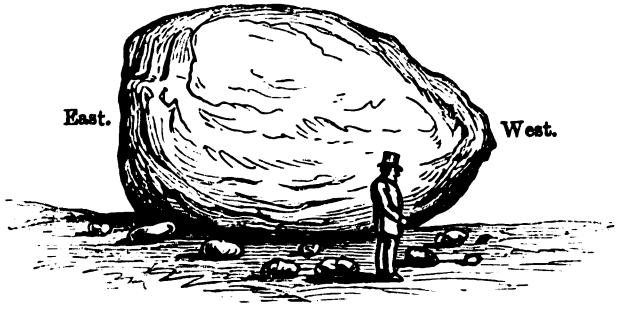
north of Luss (see *Transactions*, vol. vii., p. 174), the large boulder on the hillside above Arden, the "Jim Crow" boulder near Kirn (which the Reporter is certainly in error in stating has its narrow end pointing up the loch), the "black boulder" near Ashton, Gourock, and many others. So that the boulders alluded to as found on the western side of Knapdale, with their narrow ends pointing seaward, seem to us to prove exactly the reverse of what is concluded from them—not that they came in *from*, but that they were being moved out *towards* the western ocean. Take, for example, the "Dana boulder," a pear-shaped mass of from 70 to 80 tons weight, which rests on the shore of the island of Dana, on the northern side of Loch Sweyn. Here is a copy of the figure given of it in the Boulder Committee's *Report* (vol. xii., p. 781).



The supposition put forward in the *Report* regarding it is that it came in from the W. or S.W., and was progressing towards N.E. in that position! What natural agency could possibly incur such a waste of force as to move this mass *blunt end foremost*? Besides, what could be taking it to the north-east, in the face of a great "current" from that direction sweeping down Loch Fyne, as already admitted?

There is another point to which we wish to allude before closing. This is the frequent occurrence of boulders on the detached summits and steep slopes of hills, or on narrow ridges and knolls of rock, from which it would almost seem they could easily be dislodged—

> "As if an infant's touch could urge
> Their headlong passage down the verge."

Numerous such cases are described in the *Reports*, and some explanation is offered of their having been left in such apparently

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precarious positions. In one instance, near Oban, the Reporter says "the sides of the valley where these boulders lie are at present exceedingly steep, and it seemed marvellous that if they fell on the surface where they now lie they did not roll to the bottom." (7th *Report*, vol. xi.) In another place, he alludes to the difficulty of believing that the boulder *fell* into such a position from the end of a glacier. We may remark, however, that it need not have "fallen" at all—in fact, its being in such a position is good proof that it did not fall. It may simply have taken the ground while the glacier was shrinking, and then the gradually-diminishing ice-sheet being unable to move it further, it was left as it grounded. This seems to account better for the boulders being left on such narrow projecting points, than the stranding of icebergs, with any rocks they bore, in all possible positions. For in the first place, many of these knolls and summits are in such situations that it is impossible to see how an iceberg, even under the most skilful navigation, could get to them—one near Tarbert, on Loch Fyne, for example, being on a detached eminence quite surrounded by hills. (Vol. xii., p. 775.) And then, secondly, supposing the iceberg did get there, it is difficult to believe that such an unstable mass could leave any part of its rocky burden, if it had any, so exactly poised in that position. So great is this difficulty, indeed, that the Convener, without abandoning his main theory, propounds a subsidiary one to get over it. He suggests that "probably when these boulders arrived, the valley was filled with gravel, and that as the gravel was scoured out by streams, the boulders slowly subsided to their present position." (Vol. xi., p. 249.) In a subsequent *Report* this is explained more fully, and illustrated by a wood-cut, which we shall reproduce.

We read—"It is also a puzzle to conceive what kind of agent it was which could set these boulders upon the steep slope of a hill so gently and exactly as enabled the boulders to occupy positions of stability. Having been brought from a distance on a glacier or on floating ice, a boulder must in either case [?] have fallen with such violence as, by the reaction of concussion, to have slipped down any slope, even though far from steep. The only rational way, as it appears, of accounting for the position of these boulders is to suppose that the valleys became filled with detritus when the land was submerged, and that floating ice dropped boulders on the detritus. If the boulders were dropped near the

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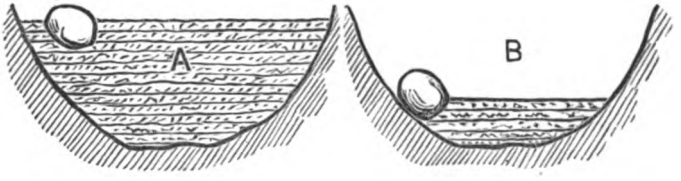
side of a valley, the boulders, as the detritus was removed by rain and mountain streams, would slowly and gradually sink till they reached the slope of the hill, and would then find a resting-place. This view is indicated by the following diagram, where A represents a boulder in detritus, and B the same boulder when the detritus was nearly all removed from the valley." (*Ib.*, p. 783.)



Now, with all respect, we should say that, granting all the conditions required, this is a most unlikely thing to happen. A boulder protects in some degree that on which it rests ; the detritus is gradually worn away on all sides of it by the denuding agencies, leaving it supported on a knoll or pillar of the detritus, like the earth-pillars at Botzen in the Tyrol, each with its stone a-top, as described and figured by Sir Charles Lyell. (*Principles*, vol. i., p. 337.) At length the pillar wearing away however slowly, becomes too slender to support its burden, and the stone *falls*, in a manner most unlikely to leave it nicely-poised on any narrow ledge underneath. Accordingly we find it stated by Sir Charles that "many of the fallen blocks, once the cappings of pillars which have disappeared, are now seen in the bed of the torrent." (*Ib.*, p. 338.) This is the natural history of a boulder resting on detritus; and, indeed, it is illustrated by an instance, given in the 6th *Report*, of a large boulder in the Inveraray district, north of Loch Fyne. "It was resting," says the writer, "on a knoll of gravel, at some distance from any hills. At first I was puzzled to account for its position being so exactly on the apex of the gravel knoll. It struck me eventually that its great size and weight had been the means of protecting by covering the knoll on which it originally had been dropped. The denuding agencies which could loosen and sweep away the gravel and sand in the surrounding parts of the valley, probably did not move the boulder, and so would leave it in its original position, or nearly so." (Vol. x., p. 581.) Exactly ; but how is it to get down at length, gently and easily, to its

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narrow ledge of rock? Again, as regards the conditions—not to enlarge on the enormous quantities of detritus required by the theory now under consideration, and the question whence and by what means these were accumulated (for mere submergence does not *create* detritus)—a fatal objection to the theory is that multitudes of the boulders whose position is sought to be explained are not in valleys at all, but on isolated hill-tops, on the shoulders of high mountains, and on steep slopes overlooking wide moorlands, or the sea; so that from every point of view the explanation is incredible, and starts greater difficulties than it was intended to remove.

We had some observations to offer on the N.W. current, and the submergence of the land, so frequently alluded to in these *Reports*, but must reserve these till another opportunity.

No. XXII.—On Some Boulders near Arden, Lochlomond. By Dugald Bell. With a Plate [No. V.].

[Read 12th January, 1888.]

Though the Boulder Committee of the Royal Society of Edinburgh now rest from their labours, there are doubtless, in various parts of the country, many boulders which, notwithstanding all the care taken, that Committee have not included in their valuable *Reports*. One of these, a large and prominent mass of mica-schist on the hill above Inverbeg, near Luss, was brought under the notice of the Society a few years ago. (See *Transactions*, vol. vii., p. 172.) I wish now to call attention to one or two others, also on the western side of Lochlomond, but farther south, viz., on the hill known as *Gowk Hill* (called by the Ordnance Survey, *Cock Hill*), behind Arden.

At this point there is, as the Convener states in one of the *Reports*, "a low valley which runs up from the loch in a westerly direction. The summit level of the valley is about 150 feet above the sea. Along the south side of the valley," he continues, "a number of boulders, chiefly of primitive rocks, have been deposited. They are at a height of about 94 feet above the sea. As usual, the most frequent position is here, as elsewhere, N.W. and S.E. for the longer axis, and the sharpest end towards the west." (4th *Report*, vol. ix.) This last statement, we are convinced, is a

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mistake, and we shall refer to it later on. Meantime, we may note that the position of many of the boulders is much higher than that mentioned in this *Report*, instead of 94, being from 200 to 400 feet, and in the instance we have now to describe, about 600 feet above the sea.

The contrast between the northern and southern parts of Lochlomond has often been pointed out. In the northern part, where the lake extends among the old schistose (Lower Silurian) rocks, bare rugged hills come steeply down to the water's edge, with, in many places, little or no margin of alluvial soil at their foot. But in its southern part, where the lake expands over the softer formations (Old Red and Calciferous sandstones), the banks retire with gentler undulating slopes, and there is frequently a considerable stretch of almost level ground bordering on the shore. This is especially the case where a stream falls into the loch; if its course has been over the softer rocks referred to, it forms a much larger delta than those in the upper part of the loch, as may have been seen at the mouths of the Endrick and Fruin. In fact the delta of the Fruin occupies a great part of the "low valley" running westward behind Arden, referred to in the *Report* from which we have quoted.

This valley may be said roughly to mark the junction of the slate and sandstone rocks, having slate on its northern and sandstone on its southern side. The hill behind Arden, which forms the southern boundary of the valley, deserves a more careful investigation than we have yet bestowed upon it. It is a continuation of the same strata that appear at Balmaha on the opposite side of the loch, where a hard cherty limestone, or calcareous sandstone, much metamorphosed, is overlaid by a massive conglomerate of the Old Red Sandstone. This ridge extends across the loch, like the fragments of a ruined wall, in the chain of islands from Inch Cailleach to Inch Murren, and re-appears in the hill behind Arden, where it again mounts to a height of from 800 to 900 feet.

It is on the northern slope of this hill, at about 600 feet above the sea, that the boulders now under notice occur. There are three of them within a short distance from each other, all composed of contorted mica-schist, in which the weathering brings out the folding and crumpling of the layers very distinctly. The largest is a mass measuring 15½ feet long, 9 feet broad, and 7 feet high,

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and must therefore weigh about 73 tons. Its longer axis has a position of N.W. to S.E., or more precisely 10° N. of W. to 10° S. of E. One end is sharper and more tapering than the other. *The blunt end is towards the N.W., and the sharp end towards the S.E.* This corresponds with the position of the Inverbeg boulder already referred to.

The slope of the hill is here of considerable steepness, but well covered with soil and grass, and overgrown with wood. The large boulder rests in a slanting position, its sharper end being higher than the other, as if it were being carried diagonally across the face of the hill when its progress was arrested.

About a hundred feet lower on the hillside is a small rounded boulder of granite, rough-grained, with large crystals of flesh-coloured felspar. Similar boulders have been observed on Benbowie hill near Helensburgh; and a large one was dug out in levelling a part of the old Luss road a few years ago. Boulders of a similar granite have also been found on the opposite side of the Firth, near the Cloch Lighthouse; indeed, they are not uncommon in the Clyde district. They seem to have come from the neighbourhood of Inveraray; but some observers are disposed to trace them as far afield as Ben Cruachan.

Further down the hill, near the old castle of Banachra, other boulders of mica-schist occur—one a cubical mass of considerable size. They are also numerous on the N.W. face of Benbowie and on the hill between Helensburgh and Glen Fruin.

But the largest boulder in the district is the Callendoun boulder, also of mica-schist, first described by Mr. R. L. Jack, formerly of the Survey. Its dimensions are 28 ft. long, 18 ft. broad, and 7 ft. high, weighing therefore about 270 tons. Its position is about a mile to N.W. of Banachra, and fully 200 feet above sea-level. The direction of the longer axis is similar to those already mentioned—N.W. and S.E., with the heavier end to the N.W. In the 2nd and 10th *Reports* of the Committee it is stated to have the "sharp end to west," but this is certainly a mistake. It rests on the western bank of a small stream, running from N. to S. to join the Fruin, and stretches nearly across the ravine which the streamlet has formed. It appears at one time to have formed an obstruction to this little stream or "burn," for an old channel is seen at the western end of the stone, which the water may have occupied from time to time ere the present channel at,

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and partly under, the eastern end, had been sufficiently deepened. Of course—though we do not make much of this—other things being equal, the main channel would be formed at the narrowest end of the rock, where the obstruction was least. But the fact does not need any such consideration to support it, being quite plain to all who choose to look at it. The boulder has lately been visited with special regard to this matter. Beyond all doubt its broad end—like the stern of a huge ferry-boat—rests on the western bank of the stream; and its narrow end—like the bow of the same boat—projects eastward over the bed of the stream. The statement in the *Report* is therefore, as we have said, a mistake. The position of the longer axis may be laid down more exactly as W.N.W. and E.S.E. [See plate V.]

The Convener of the Boulder Committee thought it more probable that this boulder came from the N.W., in the direction of the Gareloch and Lochlong, than that it should have been carried down Lochlomond and then "moved at right angles to westward to gain its present site." In this we quite agree with him, not from any belief in a "general N.W. current," but simply because there is good evidence that the glaciation of this valley, or pass, was in this direction —viz., from N.W. If, however, the "sharp end" of the boulder had been to westward as stated in the *Reports*, we should have thought it a point in favour of the opposite view—viz., that the boulder was being moved *towards* the west. For, as the Convener himself remarks, when boulders are "pear-shaped" it indicates that "one end has probably undergone more friction than the opposite end." (10th *Report.*) We presume there can be no question that the end which was being moved *foremost* would undergo the greater friction, and become the sharper and more pointed in form. If there is anything at all in the position of the boulders; if the numerous instances of coincidence between their longer axis and the direction in which they have come show that they were probably left in the position in which they were being moved; if it is more likely that they would be left in that position than turned in exactly the *contrary* way, then undoubtedly the narrow end must point in the direction in which they were being moved. And this for a double reason. Not only is the foremost end made narrow by attrition; but being so, tends to *keep* it foremost, which is plainly the position of least resistance. We cannot imagine any natural agency sufficient to move these boulders at all, yet continuing to move

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them in the most disadvantageous position, with the greatest expenditure of force, in the line of greatest resistance, or broad end foremost.

So far as we are aware, none of the many observers who have written on glaciers state that there is any general uniformity of position in the fragments of rock carried forward by these icy streams, either resting on their surface or in some degree embedded in their mass. But neither do the observers state that there is no such uniformity : the point merely seems not to have been specially under their notice. Yet it appears obvious that the motion of the glacier must have a certain definite effect on the position of the rocky fragments, for these are not scattered confusedly over the surface of the glacier, but arranged in certain well-marked lines (lateral and medial moraines) curving according to its course, and this could hardly be without some effect on the position of every stone in the series. It is admitted that the smaller stones in the Boulder-clay, when striated at all, are almost invariably so in the line of their longer axis. They may have certain cross-scratches, indicating that their position has shifted a little from time to time ; but this is their main general line of striation. Also, the striation is most noticeable at their sharper end. They have evidently been pressed forward lengthways and sharp end foremost ; "fixed like gravers' tools in the ice," they have grooved and indented with long, continuous scratches (striæ) the underlying rock-surfaces over which they have passed. (*Prestwich.*) The same remarks, as regards position, must obviously apply to the larger boulders as well.

Since writing the above, we have met with an interesting observation regarding the Mueller Glacier, New Zealand. Mr. F. W. Hutton, writing from Christchurch, N.Z., 22nd March, 1888, says :—"All through the lower portion of the glacier the veined or ribboned structure is well marked, running nearly in the direction of the glacier." Then, after alluding to another system of coarser veins seen at the terminal face, but not higher up on the glacier, he continues—"The ice here contains in places numerous angular stones, principally of slate, scattered irregularly through it, and these fragments always have their broad, or cleaved, surfaces parallel to the smaller system of veins. These stones have no doubt entered the ice through the numerous moulins and crevasses which are found higher up the glacier, but as they are not found

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in bands nor in pipes they must have been moved in position by the flowing of the ice." (See *Nature*, 24th May, 1888.) Further observations of this kind are much to be desired.

The instances of conformity between the longer axis of the boulders and the direction in which they have been moved are sufficiently numerous to be noted by observers as the common or normal position. (See the Committee's *Reports*.) We submit that every instance of such conformity makes it *more probable* that the boulders were being carried forward by glaciers than by icebergs; for the latter would, of course, leave their rocky burdens in every conceivable position. So long as they were being moved forward by land ice, there is reason to believe there might be some uniformity in their position; but as soon as they became part of a floating mass or berg dropping its rocky burdens in any way, changing its shape from time to time, and touching obstructions at every possible point, all likelihood of any such uniformity was at an end. But, though so frequent as to be considered the common or normal position of the boulders, this coincidence between the direction of their longer axis and that in which they have been moved is by no means invariable or without exceptions. In the very group of boulders now under notice the two smaller ones do not coincide in position with the largest one, nor with each other. They seem to have fallen or been left in their places without any definite arrangement. Nor indeed, when we consider the circumstances in which they must have been left by the melting and retreat of the ice, even assuming it was land ice, can we expect an absolute uniformity in this respect. What Dr. Prestwich has said to explain the mixture of striated and unstriated fragments in the Boulder-clay applies to this also:—"As the terminal moraine of a glacier contains both the angular, unworn fragments fallen from the steep precipices bounding the glacier in its course, together with the ground, worn, and scratched fragments held and carried down in the bottom ice over the rocky bed of the glacier, this moraine consists of a variable proportion of rough, angular fragments, with a certain proportion of worn and striated fragments, the relative numbers varying, of course, according to the character of the country traversed. ("Geology," vol. i., p. 178.) From the numerous instances of conformity to which we have referred, chiefly remarkable, we think, among the *larger* boulders, it looks as if these, being more deeply embedded in the ice and

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sinking gradually with it as it shrank, were ultimately left in the positions in which they were being moved; while many of the smaller ones fell in diverse directions from the melting and diminishing surface of the glacier. A general uniformity of position in the boulders seems a cogent argument against the action of icebergs, but even numerous exceptions to that uniformity seem no argument against the action of glaciers. Land ice could produce both the general uniformity and the occasional exceptions; floating ice could not produce the uniformity. We might add that neither could it produce the fine regular striæ on subjacent rocks as well as on the transported fragments, and the mingling of near and distant kinds of the latter; but to this we have referred elsewhere.

Whatever doubt there may be as to the direction in which *some* boulders have come, there can be none with regard to these Arden boulders: no one can possibly imagine that they came from S. or S.E. They were certainly being carried from N. or N.W.; and, with regard to the principal one, there can also be no doubt as to its longer axis being in the direction of transport, and its narrower end pointing S.E. This, as far as it goes, and taken in connection with other similar cases, is, we think, in favour of land ice.

As we remarked with regard to the Inverbeg boulder, "the higher such boulders are found—especially those of large size—the greater is the difficulty of supposing them to have been borne by bergs. For, keeping in mind the small floating power of ice—only about one eighth of the mass being above water and seven eighths under it—this would necessitate a very great submergence; in the case before us probably not less than twice the height at which the boulder is found. [The Inverbeg boulder is about 1,000 feet above sea-level.] And a submergence of 2,000 feet, or thereby, would so narrow the land surface of our country that we may ask, where could such extensive snowfields and icefields be found as were required to produce bergs of the size indicated?" (*Transactions*, vol. vii., p. 175.)

We do not deny that some boulders may have been carried by icebergs; but we believe they were comparatively few in number, and restricted to the lower levels of the country. As Dr. A. Geikie observes—"Erratic blocks have probably in the vast majority of cases been dispersed by land ice, and not by floating ice." He also remarks that though brought down originally by

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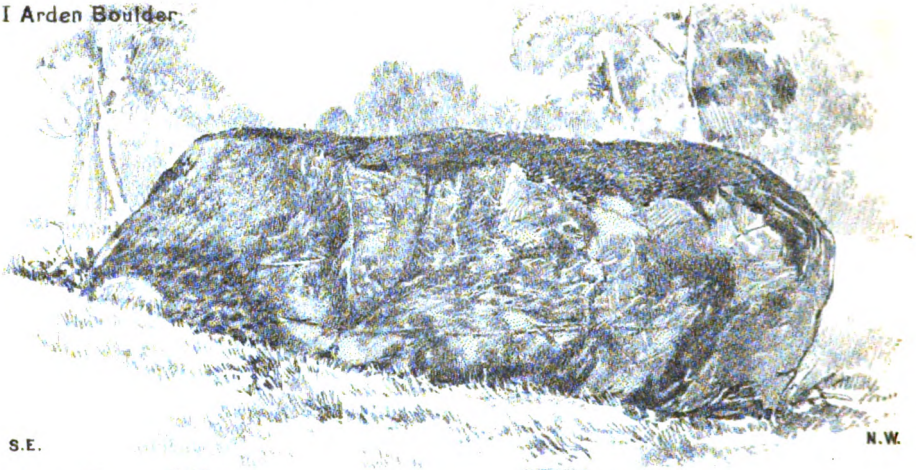
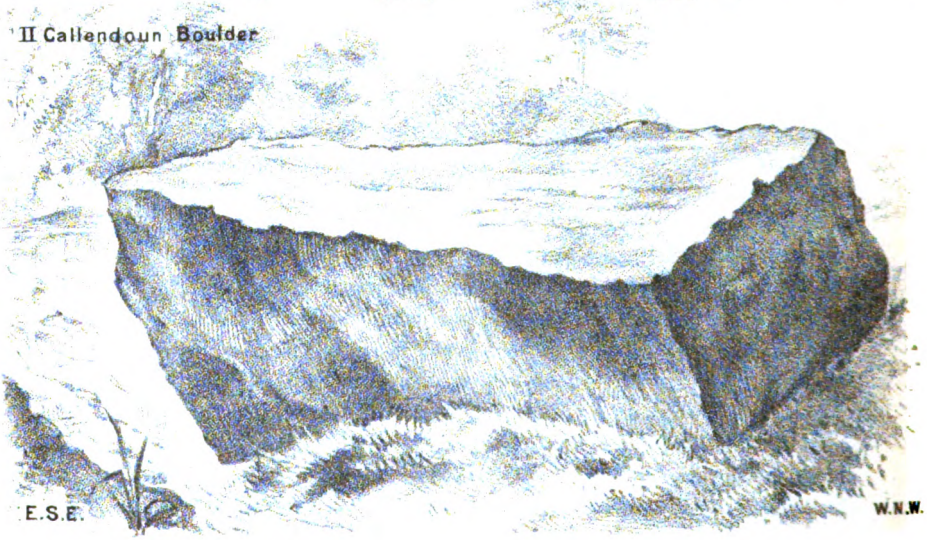
I Arden Boulder.



II Callendoun Boulder.



III. "Jim Crow" Boulder, Kirn.

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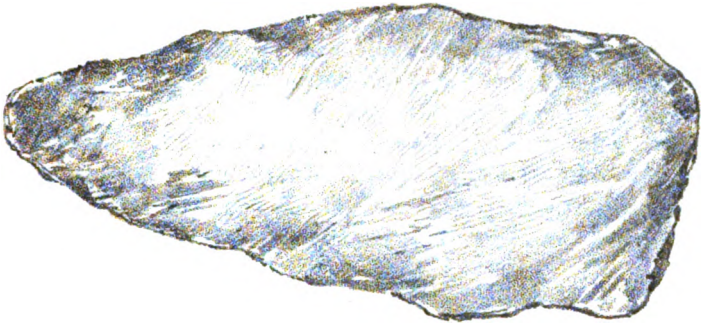
I Surfaces.

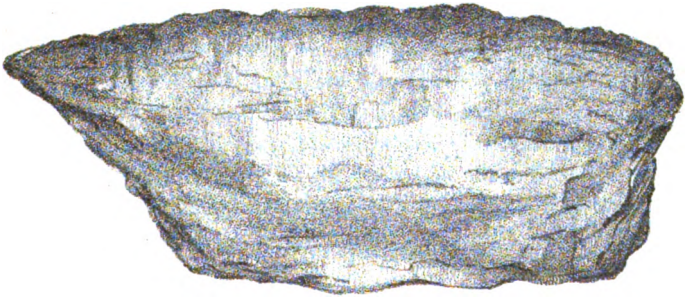


S.E. N.W.

II

E.S.E. W.N.W.

III



S.S.E. N.N.W.

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land ice, "they may in some cases have been shifted about by floating ice" during a subsequent period of partial submergence. ("Text-Book," p. 897.) In any case, we believe such sea-borne boulders will be found only far down in the main valleys, and near the present coast-line of the country; and will show only in the rarest instances, and by accident, so to speak, any relation between their position and the direction in which they have come.

[NOTE.—On one point we may add a note before closing. It may be asked, if the glaciation of this pass or valley between Arden and Helensburgh was from the N.W., why do we not accept it as evidence in favour of a general inflowing current from the N.W.? We reply, because it is quite a local phenomenon. A little further down the Firth the glaciation was as clearly from N. and N.E.; and in parts of Ayrshire it was even from S. and S.E.—dependent entirely on the position of the locality in regard to the principal neighbouring mountain ranges.

There is good evidence that the ice at this point—from the great coalescing glaciers of Loch Long, Loch Goil, and the Holy Loch—so filled the present channel of the Clyde that it passed straight over the hills on either hand into the country beyond. It passed to S. and S.E. over the hills behind Greenock and Port-Glasgow, striating the hard trap rocks there in a most remarkable manner; and also, in a similar direction, over these hills between Helensburgh and Loch Lomond. If the probable mass of the Loch Lomond ice be urged as an objection to this, we should reply that *it* also partook of this local S.E. movement; towards the southern end of the loch, it seems to have been largely deflected eastwards into the Balfron valley and through the "gap of Lennox," along the flanks of the Campsie hills. In short, the glaciation was south-eastwards here, because this tract is on the south-eastern side of the main mountain ranges. The lower part of the Firth of Clyde was so choked with ice flowing south and south-westwards from the same ranges, and from the southern uplands, that the ice at this point could not find egress in that direction; so it gradually extended eastwards, and held its way across the main valleys of the country towards the German Ocean. But from this fact no inference can be drawn in favour of a great inflowing current from the N.W. sweeping over the country generally. June, 1888.]

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No. XXIII.—Some Notes on the Geology of the District about Tarbert, Lochfyne.

By Thomas Scott, *Corresponding Member, Assistant Naturalist to the Fishery Board for Scotland.*

[Read 10th February, 1887.]

Having been located for some time in Tarbert, Lochfyne, I had an occasional opportunity of making observations on the geological features of the district, but as there is in its general aspect so much the appearance of sameness, some time elapses ere one begins to become acquainted with details. Though the leisure at my command did not permit of an extensive examination, still the following notes on a few objects which came under my own observation may not be without some general interest.

The rocks about Tarbert, when somewhat closely examined, are seen to vary very much in their general aspect, in their structure, and in the amount of folding they have undergone. In some places they present a comparatively even surface, while in others disintegration has proceeded in such a way as to give them an exceedingly ragged appearance. This diversity in surface configuration is of course owing very much to difference in mineral structure, and while there are instances where there is little apparent folding, there are others where the convolutions are of the most complicated nature, and where the beds are very much contorted, besides being built up of harder and softer laminæ. In such cases, and where the rock has been subjected to a great deal of weathering, the appearance presented is sometimes very fantastic.

Among the hills to the northward above Glen Rolloch, and about an hour's walk from the village of Tarbert, is a little loch called Loch-na-Kenna. At its eastern end where the rocks rise abruptly from the strand, they are very unequal in their structure, very contorted, and weathering has imparted to them a strange and grotesque appearance. In some places there are beds of a coarse-grained sandstone apparently little altered in structure, which alternate with others of a bluish schist, and at the north-east corner with thin calcareous beds. The rock, which is of a brownish colour, is not truly crystalline, though rather hard. It contains,

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besides calcium carbonate, a good deal of carbonate of magnesium and some carbonate of iron. From the proportions in which these occur they are seen to agree very closely with some forms of ankerite. The following is an analysis of one of the specimens I obtained—$CaCO_3$ 52·94. $MgCO_3$ 35·16. $FeCO_3$ 11·60. SiO_2 (sand) 30. J. D. Dana, in his "System of Mineralogy," 1883, p. 683, gives an analysis by Kühn of a specimen of ankerite from Schneeberg, as follows:—$CaCO_3$ 52·64. $MgCO_3$ 36·35. $FeCO_3$ 12·40. $MnCO_3$ 0·34. In the Loch-na-Kenna specimen there is therefore a nearly similar proportion of calcium carbonate and scarcely 1 per cent. less of magnesia and iron, but no manganese, as in the Schneeberg specimen, where it reaches only 0·34 per cent. There is a little silica, probably due to the presence of minute quartz crystals. Besides agreeing so closely in mineral structure with the ankerite from Schneeberg, it fulfils another condition given by Dana as a characteristic of this mineral in dissolving with very little if any effervescence in the presence of cold H.Cl. With dolomite, on the other hand, under like conditions the effervescence is violent. This seems therefore to be a true ankerite. Possibly this mineral is widely distributed among the rocks about Tarbert, for in a specimen of tourmaline from White Shore Bay, East Loch, Tarbert, which I submitted to Mr. John Young, F.G.S., he says that besides tourmaline and quartz "there is apparently dolomite present, which is seen passing into ankerite."

On the west and north-west sides of Loch-na-Kenna, which are quite shallow, and where water lilies are very plentiful, there is an extensive accumulation of mud. In some places it is moderately firm, in others exceedingly soft, so that great care is necessary when walking over it, otherwise one may find oneself up to the knees in sticky ooze before he knows where he is. Nearly buried in this mud are the trunks of several apparently large trees, though how they came there is a mystery. The nearest living trees are, I think, growing down in Glen Rolloch, so that probably those lying prone in and about this loch are the mementoes of a time when the surrounding hills were clothed with a greater wealth of vegetation than they are now able to support. There are other points of interest connected with this little loch which I must pass over in the meantime.

Limestone, as has been pointed out by Mr. James White, in his paper read to this Society in October, 1885 [*Transactions*, vol. viii.

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p. 111], is by no means uncommon about Tarbert, being found in massive beds as well as in veins, and also entering largely into the composition of many of the rocks in the neighbourhood. In some places it occurs as a highly crystalline and nearly pure calc-spar, though it very often contains iron and magnesium carbonates. The remains of a fine vein are seen by the roadside a little east of the "Inverary quay," though now very little of it is left. A bit of it which I had analyzed gave the following results—$CaCO_3$92·35. $MgCO_3$2·80. $FeCO_3$4·26. SiO_2·59.—so that it may be considered a ferrocalcite. The analysis of a specimen by Hunt, as given by Dana in the work already quoted, p. 683, is $CaCO_3$93·90. $MgCO_3$1·59. $FeCO_3$4·64. It differs little from the above, except that the Tarbert specimen contains 1·21 more of magnesium carbonate.

Iron in the form of pyrites also occurs in this district. I found it somewhat plentiful in some rocks lying between the "Columba wharf" and the old concrete pier, and which were being blasted in connection with the carrying out of the new drainage scheme.

Several specimens of menaccanite were also found during last summer, most of them being got on the south side of east Loch Tarbert. This mineral was first observed by my friend, Mr. Robt. Hamilton, C.E., and, as far as I know, occurred in every instance in detached boulders of quartzose schist.

Besides the common white quartz so abundant in many of the rocks around Tarbert, a semi-transparent form having a vitreous lustre occurs, and in several places it is found combined with iron in the form of ferruginous quartz, but not very plentifully. In some of the rocks tourmaline is seen to be exceedingly abundant. It usually occurs in long crystals, generally not thicker than a small needle, which are scattered more or less plentifully through the matrix. A cross section of a crystal shows a somewhat triangular outline, but when closely examined it is found to be very obscurely 9-sided. Sometimes accumulations of pure crystals are met with, as if filling up what may have been cavities in the rock. Though generally crystalline, these occasionally assume an amorphous form, the crystalline character being almost entirely lost, but in the surrounding quartz or calcareous material with which the tourmaline is, in this form, usually associated, crystals are seen branching off in different directions. It is connected with this form of tourmaline that what appears to be dolomite passing into ankerite, previously referred to as observed by Mr. Young, is

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seen to occur; this amorphous condition probably resulting from the mineral while in a crystalline state becoming altered through combination with other elements, and not *vice versa*. A careful analysis might determine this.

Wherever tourmaline is abundant in the rocks, they present an extremely ragged appearance, and seem ill adapted to withstand the tear and wear to which they are subjected by the weather. In the neighbourhood of Garvald Point, where I had an opportunity of making some observations, the tourmaline schists are seen to extend from the surface down to a little above high-water mark. Below them, and extending as far at least as low-water mark, the rock is quite different, being harder, much more uniform in structure, and containing a good deal of quartz, and therefore less easily weathered. The contrast between the two rocks is very striking, the upper being rugged and weather-worn, the lower exhibiting a comparatively even and uninjured surface. But though thus different in structure, the boundary line between them is by no means clearly defined. I have noticed in other places in the neighbourhood where these rocks are exposed, as round the head of East Loch Tarbert, that they retain their relative positions. These tourmaline schists have been observed on the Cantyre side of the loch, as well as on the Knapdale side.

A short way round from White Shore Bay, towards "M'Arthur's Island," East Loch Tarbert, a thick bed of talcose schist is observed. It is well tilted up, and being comparatively soft, the water has formed a deep indentation on both sides of the headland across which it passes diagonally. Possibly the time is not far distant when this headland will have become another "Skeiran," round which the wintry waves will rear their whitened crests. This schist, however, though not a pure soap-stone, evidently contains a good deal of talc, as it feels very "soapy" when rubbed.

Mr. White, in his paper on Tarbert, already referred to, mentions some interesting phenomena peculiar to the "glacial period" as exhibited in the form assumed by the rocky knolls seen everywhere in the district, and in the occurrence of numerous perched blocks. There is also evidence that the laminated shell-bearing clays of that period—clays which were so fully exposed in section at Garvel Park, Greenock — were at one time extensively developed here. As long ago as 1869, Mr. David Robertson, F.G.S., described a shell-bearing clay, which he examined at the

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north corner of East Loch Tarbert, and which was acknowledged to be of Post-tertiary age. I have from Mr. Robertson's description been able to identify this deposit. It is seen on both sides of the stream which in his paper is called the "Black Burn," and can be followed for some distance up from the shore, more especially on the south side of the stream. The same deposit can be traced nearly all round the shore at the head of the "Douchlan" —the local name for this part of the loch—into which the Black Burn runs, and when the fishermen happen to dig holes here at extreme low water, for erecting poles for net-drying purposes, this clay is generally turned up, and the same thing occurs at other places round the head of the loch. Last year when the drainage operations were being carried on, a trench more or less deep was cut from a short way below the "Inveraray quay" to the old concrete pier—that is, along a good part of the south shore of the loch—where for a considerable distance on both sides of M'Tavish's boat-building shed, fossiliferous Post-tertiary clay was dug into—the clay being in some places mixed with a good deal of sand. Among the shells turned up were many examples of *Pecten Islandicus*, as well as of *Astarte borealis*, but I did not notice any of these shells about "Douchlan," the only truly boreal shell I saw there being *Tellina calcaria*. But I did not examine this clay very minutely, for the work in connection with the Fishery Board's investigations required all the attention that could at the time be given to it. Besides this extensive range of these shell-bearing clays round East Loch Tarbert, similar clay containing *Pecten Islandicus* was observed on the shore of Lochfyne in a little bay separated from the White Shore by the low ground stretching back from Garvald point. Whether this clay extends across to the White Shore or not I cannot say.

From the fact that these clays extend so far round East Loch Tarbert, it requires, I think, no great stretch of imagination to conceive that they once occupied the greater part at least of the area now covered by the loch. Whether its bed had been previously scooped out by ice action or otherwise may not be so easily determined, but, however it may have been formed, it seems to have been gradually more or less filled up with deposits of mud and other debris during the ice age, till a somewhat higher level was reached than that of the present high-water mark; and that afterwards these deposits were worn down and carried away, possibly to form part of the submarine banks in Lochfyne, while only

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around the margins of East Loch Tarbert were patches left to indicate what was once a comparatively large land surface.

In one of our hauls with the dredge in Lochfyne, a little south of Tarbert, and in moderately deep water, a valve of *Panopæa Norvegica* was fished up, but its occurrence was so unusual, and it had such an old-world look about it, that we refrained from giving it a place in our list of recent marine forms. It may perhaps have been washed from the clay which was carried out by the sea from East Loch Tarbert.

In concluding these remarks I wish to acknowledge the kindness of Mr. John Young, F.G.S.—who is always ready to lend a helping hand to honest seekers after knowledge—for naming the specimens of minerals from Tarbert, and for information connected therewith. The analyses of ankerite and ferrocalcite were made by my son, who is indebted to Mr. J. W. Biggart, F.C.S., F.I.C., public analyst for Greenock, for valuable hints on correct quantitative estimation.

No. XXIV.—Some Notes on a Bed of Shell-bearing Clay at Roxburgh Street, Greenock. By Thomas Scott, *Corresponding Member, Assistant Naturalist to the Fishery Board for Scotland.* With a Plate [No. VI.].

[Read 8th March, 1888.]

Almost fifty years have now passed away since the late James Smith of Jordanhill, in a paper read to the Wernerian Society, "On the Elevated Marine Beds of the Basin of the Clyde," called attention to the existence of a laminated clay containing marine shells which had been exposed near Greenock through the operations connected with the construction of the Caledonian Railway from Glasgow. This clay occurred in the vicinity of the Cartsdyke Station, and was therefore probably a continuation of the extensive deposit which has been exposed during recent years—first when the Graving Dock at Garvel Park was formed, and latterly and more extensively, during the formation of the James Watt Wet Dock at the same place.

Although the number and variety of the organisms collected from the clays which were exposed while the excavations for the James Watt Dock were being proceeded with greatly exceeded

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those found anywhere else in Clydesdale, and a very valuable and interesting chapter was thus added to the Post-pliocene geology of the West of Scotland, yet in one way the interest attaching to the discovery of the Cartsdyke clay was greater, for at a time when this department of the science was not so well understood as it is now, a notable addition was here made to the rapidly accumulating evidence that within comparatively recent times a very considerable change had taken place not only in the climatal conditions of the British Islands, but also in the relative levels of sea and land. The Cartsdyke deposit was 50 feet above the present sea-level, while the shell-clay at Garvel Park was in part only a few feet above, and very much of it considerably below, the same level.

During the construction of the branch line of the Glasgow and South-Western Railway which connects the main line with the new docks at Garvel Park, a clay containing the usual boreal shells was cut into a little west of the Bogston Station of the Caledonian Railway. This clay had an elevation somewhat similar to that at Garvel Park, and was possibly a continuation of it. Another Post-pliocene clay was cut into during the excavation for a sewer across what is locally known as the "Battery Field," and near the junction of the High and Low Gourock Roads. The same bed was subsequently exposed at the west end of Westbourne Terrace and behind the garden attached to the old Gourock Toll-house, where sand was being dug out for building purposes. (A short paper on this deposit was read to the Society by Mr. Thomas Steel, see *Transactions*, vol. vi., p. 261.) This deposit also was very little elevated above sea-level, so that the clay which was exposed at Cartsdyke, and examined and described by Mr. Smith of Jordanhill, was, until quite recently, the highest recorded in the neighbourhood of Greenock.

In the construction of the extension of the Caledonian Railway, which is at present being carried out from near the Cathcart Street Station, Greenock, to the Steamboat Quay at Gourock, extensive excavations in the form of tunnelling and open cutting have had to be made. One of these open cuttings is at Roxburgh Street, Greenock, where the old Highlanders' Academy stood [See Plate vi., plan of Greenock.] In making this cutting a bed of sandy clay, containing the remains of marine and other organisms, has been exposed, and appears to be of Post-pliocene

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age. I examined this clay early in December last year, and found *Tellina calcaria* of frequent occurrence, the spines and plates of *Strongylocentrotus* (*Echinus*) *Dröbachiensis* and *Mytilus modiolus* and *edulis*. Very few species of shells, however, were observed. Mosses, seeds, and leaves of land plants were common. Marine Ostracoda were fairly numerous, but Foraminifera, though comparatively common, included but few species. It should be mentioned, however, that I had an opportunity of examining only a very small portion of the clay, so that there is every likelihood, had a considerable quantity of it been examined, that a much larger number of species would have been observed than those actually recorded in the appended list. All the shells and other calcareous remains were very fragile, so that it was difficult to secure anything like a perfect specimen; even such heavily-built shells as *Mytilus modiolus* being so much eroded that frequently little more than the epidermis was left.

The section, as I saw it in December, consisted of a thin superficial layer, next a thick bed of nearly pure sand, a sandy clay containing marine shells, a thick unstratified deposit of sandy Till, with numerous boulders, and, last, Calciferous sandstone of unknown thickness. The following measurements, which may be relied on as practically correct, were made for me by Mr. Patrick Grant, Clerk of Works, Greenock:—

Surface of ground at corner of Duncan and Roxburgh Streets, 72 feet 5 inches above sea-level.

(1) Thin superficial layer, from 9 inches to 1 foot thick.

(2) Surface of ground to top of shell-clay, 10 feet—nearly pure sand, excluding (1).

(3) Surface of ground to bottom of shell-clay, 14 feet (shell-clay, 4 feet thick).

(4) Surface of ground to top of rock, 30 feet (Till, underlying shell-clay, 16 feet).

It will be seen from these measurements that the bottom of the shell-clay is about 58½ feet, and the top 62½ feet, above sea-level, and therefore considerably higher than the Cartsdyke deposit.

The following is a list of remains observed in the small quantity of clay examined by me:—

PLANTÆ.

MUSCI.

A few species (not yet identified).

PHANEROGAMS.

Leaves, seeds, and fruits.

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The seeds and fruits, of which there appears to be at least ten different kinds, are representatives of, among others, the following orders :—Caryophylleæ, Polygonaceæ, Cyperaceæ, Gramineæ.

[Since this paper was written I have submitted the seeds and fruits to Mr. Clement Reid, F.G.S. (of the Geological Survey), and he has been able to identify the following—*Potentilla tormentilla, Sibth.; Taraxacum officinale*, Wig.; *Thymus serpyllum* (?), L.; *Rumex*, sp.; *Atriplex patula*, L.; *Potamogeton*, sp.; *Carex dioica* (?), L.; *Anthoxanthum odoratum*, L.; and *Poa trivialis*, L. Two others have not yet been identified—June, 1888.]

Layers of vegetable matter were frequent all through the clay, and had a large quantity of it been examined, no doubt other plant remains would have been observed. No remains of Marine Algæ were noticed, but this was the more likely owing to the small quantity of clay examined, and partly to the bad state of preservation in which all the remains were, than to the real absence of marine vegetation.

FORAMINIFERA.

Reophax fusiformis, Will. Appeared scarce.
Polymorphina lactea, W. and J.
,, *compressa*, D'Orb.
Truncatulina lobatula, Walker. Frequent.
Polystomella striato-punctata, F. and M. Common.
Nonionina depressula, W. and J. Frequent.

ECHINODERMATA.

Echinus (*Strongylocentrotus*) *Dröbachiensis*, Müll. Parts of test, spines, etc., frequent.

OSTRACODA.

Cythere lutea, Müll.
,, *viridis*, Müll.
,, *pellucida*, Baird.
,, *porcellanea*, Brady.
,, *tuberculata*, G. O. Sars.
,, *concinna*, Jones.
,, *angulata*, G. O. Sars.
,, *villosa*, G. O. Sars.
Cytheridea papillosa, Bosquet.
Cytherura nigrescens, Baird.
,, *undata*, G. O. Sars.
,, *flavescens*, Brady.
Paradoxostoma variabile, Baird.

} These were all more or less frequent, but not very well preserved.

DECAPODA.

Only part of a claw, possibly of a Hermit-crab, was observed.

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CIRRIPEDIA.

Balanus crenatus, Brug. Scarce.

INSECTA.

Wingcases (Elytra) of two Beetles.

MOLLUSCA.

Mytilus edulis, Lin. Very common, especially young.
,, *modiolus*, F. and H. Frequent, but very much eroded and fragile.
Tellina calcaria, Chemn. Very common, but fragile.
Littorina obtusata, Lin. Frequent.
,, *rudis*, Maton. Frequent.

Although from the preceding list such characteristic species as *Pecten Islandicus* and *Astarte borealis* are absent, a more extended search might have brought to light one or both of them. But leaving these shells out of account altogether, the fact that *Tellina calcaria* was of common occurrence and perfect, though very fragile, points to the reasonable inference that the molluscs had lived and died where we found them—that they had not been washed into the clay from an older deposit—and thus affords fairly sufficient grounds for considering this clay to be of Post-pliocene age. [I have since learned that *Pecten Islandicus* has now been found near where the shells here recorded occurred—June, 1888.]

No. XXV.—Notes on the Jordanhill Coalfield.

By James S. M'Lennan.

[Read 10th November, 1887.]

This Coalfield is situated partly in the counties of Renfrew and Lanark, and comprises parts of the parishes of Renfrew and Govan. Its length from north to south is somewhat over a mile, and from east to west rather more than 1½ miles, extending over an area of nearly 1,000 acres.

The dip of the strata in the eastern portion is to the north, and in the western towards the north-east.

In the centre of the field is a deposit of Brick clay, having an average thickness of 18 feet. It consists of two parts—the upper of a brownish-yellow colour, and unstratified, some 7 feet in thickness; and the lower of a blackish-blue colour, disposed in layers of various thicknesses and about 11 feet in depth. In these are

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found the shelly clays or "Post-Tertiary Fossiliferous Beds" associated with the name of James Smith of Jordanhill, who, about forty years ago, directed his attention to these deposits; while, since his time, much additional knowledge has been gained concerning them from the researches of several members of our Society—notably Mr. David Robertson.

All over this district occurs beneath the surface a deposit of Boulder-clay. It thins out towards the east, and in the western portion of the field attains a thickness of 25 or 26 feet, its average depth being about 18 feet. The boulders which it encloses are mostly of local origin, or have been brought from a distance of less than 10 miles, 60 per cent. of them being derived from the white sandstone and shale, 30 per cent. from the traps of the Kilpatrick Hills, 10 per cent. from the slate and Silurian hills of Dumbarton and Argyll shires, and 1 per cent. from the granites of the Highlands.

Underneath the Boulder-clay lie several layers of shale, and in No. 8 pit a post of white sandstone some 12 feet thick was found. It is a coarse-grained stone, and somewhat hard in quality.

In the Greenlea pit, situated near the centre of the field, at a distance of 9 fathoms from the surface, occurs the first seam of coal —known as the "Wee Coal." It is of small extent, some 40 acres, and is now all wrought out. Its thickness is 22 inches, and it is a house coal of fair quality. It lies on a pavement of thin layers of sandstone known as "faiks."

The next coal seam found in the same pit is the "Main Coal," which lies at a depth of 16 fathoms below the "Wee Coal," or 25 fathoms from the surface. It has a thickness of 2 feet 2 inches in some parts of the field, but in the western portion it is 4½ feet; and it crops out to the south near Skaterigg Farm, and a little to the west of Jordanhill mansion-house; also on the west side near the Joint Hospital. This same coal underlies the lands of Knightswood, Cloberhill, Drumchapel, Garscube, and Kelvinside. In the second last mentioned locality it is cut out by a large trap dyke running south-west and north-east, which is seen near the railway bridge over the Kelvin at Maryhill, and to the west at the old Netherton quarry. Beyond this it is found in all the pits westward, where it causes an upthrow of 30 fathoms, while in the Cloberhill pits still further to the west it is only 13 fathoms.

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The seam is continuous, being free from "troubles," and its contents form a good kitchen coal. It has been wrought in this district for two hundred years, on the stoop-and-room system. Some of the "stoops" were 4 feet square, and were not left at regular intervals, nor of a uniform size. In that part of the field where these workings were discovered they had a depth of only 14 fathoms from the surface. The roads were narrow, about 6 feet wide, and were cut through the coal in the form of an arch, in a neat and workmanlike manner. In one of these old workings some wooden tools shod with iron, and wooden shovels, were found.

In the soft clay on the pavement prints of naked feet were seen, and it would seem that women were employed in carrying the coals on their backs to the pit mouth. In proof of this there is a story current in the district that on a Glasgow Fair Saturday, somewhere about the year 1690, three women were killed in a pit close to the North Lodge at Jordanhill by the falling-in of the "door heads," as they were termed.

When the workmen were engaged a few years ago in making a connection from the Greenlea pit to No. 14 pit, Skaterigg, they came upon some old workings in this coal which had been made about eighty years before. One of these workings was the level from which the "places" had been broken away. The regularity of the work was most marked—the places were driven 18 feet wide, with stoops 12 feet between them; and these working places extended 36 feet before through places were put in, thus leaving stoops 36 feet by 12 feet to support the roof. The coal here was 2 feet 2 inches in depth.

Descending some 12 fathoms lower, or 37 fathoms from the surface, we come upon the Old Blackband Ironstone. Previous to 1837 it was called by the name of the "drugget stane" from its striped appearance; and it had been gone through in four of the pits while they were sinking, but was not then known to be an ironstone. It is said that about that time a manager from the Carron Ironworks paid a visit to this district, and seeing pieces of the then-called "drugget stane" lying about, told the people that it was an excellent blackband ironstone. It lies in a basin in Jordanhill and Skaterigg, and covers about 200 acres in extent. In average thickness it is about 1½ feet, and is persistent over its entire area. It was exhausted in 1867, after being wrought for 30 years. It was of excellent quality, 42 cwts. of the raw ironstone

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making 1 ton of pig iron. The greater portion of the out-put was sent by the Canal to Dundyvan Ironworks and there smelted. In the neighbouring lands of Knightswood, Garscube, and Kelvinside a seam of coal takes the place of this blackband; and in the first-named locality it has been wrought as a steam coal.

Some 3½ fathoms below the old blackband ironstone, or 41½ fathoms from the surface, lies the Gas Coal, which covers as large an area as the blackband above it. It consists of 4 inches of free coal, 3 inches of "rad" or wild gas coal, and 9 inches of gas coal. In the western portion of the seam the free coal increases to 7 inches, and over one fourth of its entire extent it loses the gas coal and becomes free coal, while the wild gas coal grows in thickness. This coal is also found in the adjacent lands of Knightswood, Garscube, Cloberhill, and Drumchapel. In the first of these localities it was of excellent quality, and very easily obtained, as it lay at no great depth from the surface.

At a depth of 27 fathoms below the gas coal, or 68½ fathoms from the surface, there is found the Blackband Ironstone, which was first discovered in the lands of Garscadden. Above this ironstone, in about 13 fathoms there are found 22 layers of clayband ironstone, varying from 2 inches to 14 inches in thickness; and 4 fathoms above these is a seam 9 inches thick composed of shells. In Jordanhill this blackband occupies some 60 acres of the same area as the gas coal; but with the exception of some 2 acres it has all been wrought out. It is found in Knightswood, and Garscadden, but not in Drumchapel. Its thickness is about 9 inches, with sandstone for its pavement, and "blaes" for its roof. It is of good quality, 2½ tons of the raw material making 1 ton of iron. The name by which it is known in the district is the "brown stane." At Garscadden and Knightswood it is called the upper blackband ironstone.

The next to be noticed in this descending series is a layer of clayband ironstone, some 16 fathoms further down, or 84½ fathoms from the surface, known as the "Garibaldi." It was so named, in honour of the great Italian hero, by the late Mr. A. M'Luckie, manager at Jordanhill, in 1860. It is made up of 6 inches of ironstone on the top, 2 feet 9 inches of "blaes" in the middle, and 8 inches of ironstone in the bottom. This clayband has a pretty wide range, being found all round by Maryhill, Kelvinside, and Knightswood. It is the best clayband ironstone in the district, 45 cwts. of the raw material making 1 ton of iron.

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Some 3 fathoms above the Garibaldi seam occurs a thin seam of coal, which in Jordanhill is the equivalent of the Garscadden and Govan lower blackband ironstone.

In most of the pits to the west some 2 fathoms below the Garibaldi, or 86 fathoms down, a 14-inch seam of coal is met with, which as it goes to the south turns into 9 inches of ironstone, the rest being coal mixed with ironstone. It has not been much mined, being difficult to work. It is supposed to extend through some 50 acres of this coalfield, and it has been found and wrought at Cardonald, on the south side of the Clyde.

This seam, which was a coal, was so close to the Garibaldi in Garscadden that it was wrought along with it; but the working of it was stopped, as the "blaes" between the two layers of ironstone was over 5 feet in thickness, which thus made the workings far too high.

In Garscadden, 42 fathoms below the Garibaldi, or 126 fathoms from the surface in Jordanhill, the Johnstone Lower Clayband Ironstone is found. It underlies the Jordanhill and Knightswood coalfields, and though not mined in the former locality, it has been met with in several of the bores that have been put down there in different parts. In the latter district it was wrought in No. 10 pit, but was rather dangerous to work, owing to its having a bad roof. It is made up of 14 inches of ironstone on the top, 16 inches of "blaes" in the middle, and 18 inches of ironstone in the bottom.

Some 60 fathoms below that, or 186 fathoms from the surface, occurs the Hurlet Limestone and Coal, which have not as yet been reached in Jordanhill. Above this coal is the layer which contains the balls from which copperas is manufactured. The coal is 4 feet in thickness. Both it and the limestone have been worked at Garscadden, where, some 40 fathoms above, a seam of ironstone was found (supposed to be the same as the Nitshill Clayband), but so thin that it could not be wrought with profit, although said to be the best clayband ironstone in Scotland.

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No. XXVI.—Note on the Composition of a Carbonaceous Sandstone. By G. G. Henderson, M.A., B.Sc., *Assistant to the Professor of Chemistry, University of Glasgow.*

[Read 14th April, 1887.]

The peculiar Sandstone described in this note occurs at Tweed River Heads, New South Wales, but unfortunately I have been unable to obtain any information as to the character of the deposit or the nature of the associated strata; it would, however, appear, so far as can be judged from a hand specimen, to be of comparatively recent date. Some fragments of this sandstone were put into my hands by Mr. John Young, F.G.S., of the Hunterian Museum, who considered that it might possibly contain binoxide of manganese; the appearance of the stone afforded reasonable ground for this supposition. On examination, however, I found that this was not the case; the sandstone does not contain a trace of manganese, but its peculiar appearance led me to make a more exact investigation of its composition, and the hope that the results of this might be of some interest induced me to make this communication to the Society.

The sandstone is dark brown in colour, and small white granules are abundantly distributed through the binding material. It is soft, incoherent, and very friable—so much so that it is possible to rub it down to a coarse powder between the fingers. If the powder is examined under a low power of the microscope one sees numerous more or less rounded and sub-angular granules of quartz, many of which are almost perfectly transparent, and a quantity of a finely-divided brown amorphous substance. The quartz granules are evidently water-worn, and the amorphous matter has all the appearance of the product of sub-aqueous decay of vegetable matter, though I was unable to detect in it traces of vegetable structure. The sandstone has an average specific gravity of about 2·3, and when immersed in water for some time absorbs about one-tenth of its weight of that liquid, air bubbles being given off very abundantly. On ignition it gives off little or no smoke, crumbles away, and leaves an almost perfectly white residue. When heated before the blow-pipe with a little potassic nitrate it deflagrates. On exposure for some time to a temperature of 100° it loses

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from 4 per cent. to 4·5 per cent. of hygroscopic water. The composition is fairly constant, as will be seen from the following analyses of samples from two different fragments, dried at 100°:—

	1.	2.
Insoluble Silica (sand), . . .	84·35	86·10
Carbonaceous matter, . . .	14·09	12·65
Soluble Silica, ...	0·47	0·34
Oxide of Iron and Alumina, . .	0·64	0·43
Lime, Magnesia, Carbondioxide, .	traces	traces
	99·55	99·52

A glance at the figures quoted above will show that the most remarkable feature is the large proportion of carbonaceous matter present. If the sandstone is roughly powdered and treated repeatedly with water, the lighter organic matter may be washed away from the heavier mineral substances. Obtained in this way it presents when dry the appearance of a fine dark-brown powder. It is insoluble in water, alcohol, ether, benzene, petroleum spirit, carbon disulphide, and oil of turpentine, but dissolves readily in solutions of alkalies and of alkaline carbonates. The solution is dark-brown and perfectly clear, though when concentrated so dark in colour as to seem opaque; on addition of a mineral acid the organic matter is precipitated in dark-brown flocks. The carbonaceous matter therefore contained in this sandstone is one of those bodies of rather indefinite composition which are classed together under the name of *humus acids*, and which are in many cases the result of the decomposition of vegetable matter. I have not yet had an opportunity of investigating the composition of the above-mentioned substance more closely, but hope to do so before long.

It would appear then from the above brief description that the black sandstone has the character not so much of a true carbonaceous sandstone as of a kind of very sandy peat, in which the vegetable matter has so far undergone decomposition as to lose all trace of its original structure.

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No. XXVII.—Quartz as a Rock-forming Mineral.

By John Young, F.G.S., *V.P.*

[Read 9th December, 1886.]

In the few remarks which I have to bring before the Society this evening, I make no pretensions of offering any original observations on the mineral Quartz. What I have to state, for the information of the younger members, is only what has been made known during recent years in Geological Text-Books and in special papers, as to its modes of occurrence, the conditions under which it is found, and the important place it occupies, as one of the rock-forming minerals, it being estimated to form one fourth, perhaps, of the ponderable crust of the globe.

Quartz, a German miner's term for crystallized silica or rock crystal, is a mineral which is properly speaking colourless, but found of all tints when mixed with various metallic elements which are considered impurities, although sometimes they give it great beauty and interest, especially in those varieties known as gem-stones. In the scale of hardness of minerals, ranging from 1 to 10, quartz reaches 7, so that there are only 3 degrees between it and the diamond, which has a hardness of 10.

Quartz is an oxide of silicon, there being in 100 parts 53·33 of oxygen, and 46·67 of silicon, or silicium as it is sometimes termed, a dark brown powder, heavier than water, which, the base of silica, was first discovered by Berzelius in 1823, and is still only known to the scientific chemist. It is non-fusible before the blow-pipe and non-volatile. Silica or quartz possesses one or two interesting and valuable properties which may be stated here. When pure and colourless rock-crystal is heated to redness and quenched in water, it becomes opaque and friable, and if then reduced to powder, it presents one form of pure silica. In this state, when it is perfectly insoluble in water, if it be fused with three parts of carbonate of potash, it forms a glass which is soluble in water—and from such a solution, formerly called the liquor of flints, concentrated acids throw down the silica in the form of a gelatinous hydrate. If, however, the solution be diluted, and the acid gradually added, the alkali may be perfectly neutralized without any deposition of silica, which is therefore exhibited in a very soluble state; but if the solution be evaporated to dryness, the

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silica remains as insoluble as before. This solubility of hydrated silica, which when dry is perfectly insoluble, may serve to explain the occasional occurrence of silica in mineral waters, and its deposition in various chalcedonic incrustations. Silica presents also another remarkable character. If we reverse the above proportions and fuse together a mixture of one part of carbonate of potash and three of powdered rock-crystal, or of calcined flint, a transparent and fusible compound insoluble in water, in fact a glass, is obtained.

This property of ready combination with other rock-forming elements may illustrate the abundance of silica in the rocks of the earth's crust. While existing in great purity by itself, yet if we take twenty-four of the other rock-forming minerals found in plutonic and volcanic rocks, we find that silica has combined with their elements to the extent of 68 per cent. in the felspars, and in gradually lessening quantities in the others until we come to chlorite, of which it represents only about 27 per cent. It also enters largely into the composition of many other rocks although not visible in its free or crystallized condition.

Should we search for the original sources of the silica or quartz found everywhere so abundantly in the rocky crust, and scattered as loose sand over the earth's surface, we find it in the heated waters of the molten magmas out of which the various plutonic and volcanic rocks have been formed. Quartz in these rocks presents this peculiar character, that while in certain conditions it is one of the most non-fusible and insoluble of minerals, in these magmas it is found to have been one of the very last of the elements to consolidate and crystallize. This property explains how quartz in its crystalline state, and as vein quartz, comes to enclose and envelop so many other mineral substances. Prof. Dana in his "Text-book of Mineralogy," when speaking of the conditions under which it occurs, says, "Quartz crystals also occur penetrated by various minerals, such as topaz, ruby-saphire, chrysoberyl, garnet and the different species of the hornblende and pyroxene groups, kyanite, zeolites, calcite and other carbonates, rutile, stibnite, hematite, gothite, magnetite, fluorite, gold, silver, anthracite, etc." And he then adds, "As quartz has been crystallized through the aid of hot waters or of steam in all ages down to the present, and is the most common ingredient of rocks, there is good reason why it should be found thus the enveloper of other crystals." Sir Charles Lyell in

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his "Student's Manual," also remarks on this peculiarity in quartz, when speaking of the quartz of granite, and says, "As a general rule, quartz in a compact or amorphous state forms a vitreous mass serving as the base in which felspar and mica have crystallized; for although these minerals are much more fusible than silica, they have often imprinted their shapes upon the quartz.

"This fact, apparently so paradoxical, has given rise to much ingenious speculation. We should naturally have anticipated, that during cooling of the mass, the flinty portion would be the first to consolidate; and that the different varieties of felspar, as well as garnets and tourmalines, being more easily liquefied by heat, would be the last. Precisely the reverse has taken place in the passage of most granite aggregates from a fluid to a solid state, crystals of the more fusible minerals being found enveloped in hard, transparent, glassy quartz, which has often taken very faithful casts of each, so as to preserve even the microscopically minute striations on the surface of prisms of tourmaline. Various explanations of this phenomenon have been proposed by MM. de Beaumont, Fournet, and Durocher. They refer to M. Gaudin's experiments on the fusion of quartz, which show that silica as it cools has the property of remaining in a viscous state, whereas alumina (the earth of felspar) never does. This gelatinous flint is supposed to retain a considerable degree of plasticity long after the granitic mixture has reached a low temperature."

I referred at last meeting of the Society to the occurrence in vein quartz, and in the quartz of granite, of numerous fluid cavities, which indicated, in some instances at least, that the quartz in these specimens had cooled and consolidated under a pressure equal to that of 50,000 feet of overlying strata, and that this pressure prevented the escape upwards of the heated water or steam, now locked up in these fluid cavities. Also that the temperature of the rocks at this supposed depth would be equal to a dull red heat, visible in the dark. Sir Charles Lyell says that "water plays an important part in all volcanic eruptions, being so intimately mixed up with the materials of the lava that it is supposed to aid in giving mobility to the fluid mass, and that it is well known that steam escapes for months, sometimes for years, from the cavities of lava when it is cooling and consolidating." He indicates how this water comes to be present. "When rocks are melted at great depths water must be present for two reasons:

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first, because rain water and sea water are always descending through fissured and porous rocks, and must at length find their way into the regions of subterranean heat; and secondly, because in a state of combination water enters largely into the composition of some of the most common minerals, especially those of the aluminous class." Also, "the existence of water under great pressure affords no argument against our attributing an excessively high temperature to the mass with which it is mixed up. Bunsen, indeed, imagines that in Iceland water attains a white heat at a very moderate depth."

Having stated thus much regarding some of the conditions under which quartz is believed to have consolidated in the granitic and metamorphic rocks, I shall now refer to some of the differences which exist between the crystalline quartz of granite, and that found in veins, when compared with that found in beds or strata —now termed quartzite. If we examine any clean-washed pure sand, it is seen to be almost wholly composed of grains of a crystalline silica, often highly rounded from long attrition in water, but in other instances more or less angular, and sometimes showing the primitive crystalline form. This sand tells us at once that it is derivative, and that its original source, however far back in geological time it can be traced, must be sought in the crystalline quartz of the igneous rocks, and in that of metamorphic strata.

All beds of quartzite, whatever be the age of the formation in which they occur, must first have been beds of loose sand, their subsequent consolidation being due to heat and pressure, and to the intensity of the regional metamorphism to which they have been subjected. In the arenaceous strata of the earth's crust we find every degree of consolidation, varying from the loose sand of our present beaches up through various stages of hardness, until we reach a rock of almost vitreous quartz, in which the original grains of silica can, in some instances, be barely detected, so much have they been fused together through the combined action of heat and pressure.

The earliest beds of sandstone in the oldest stratified rocks must originally have derived their grains of silica from the disintegration of rocks in which the quartz existed in a free crystalline condition. It may be of interest to remember that beds of sandstone may again and again be re-formed from the disintegrated material of older beds, and that without losing any of the

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characteristics of the earlier deposits. Thus the sandstones of the Cambrian may have been formed out of those of the Laurentian rocks, those of the Silurian, Old Red Sandstone, and Carboniferous, each in their turn from the earlier sandstone formations, which again have each been exposed to denudation.

I remember that Professor Hull, while engaged on the work of the geological survey of this district, stated it to be his belief that the quartzite pebbles found in the sandstones of the Permian conglomerates of England were probably derived from the Scottish Old Red conglomerate, as no known rock in England corresponded to these pale reddish-brown quartzites, while the pebbles from the two formations seemed to be identical in colour and structure. In our own neighbourhood, on the south hill of Campsie, towards Strathblane, where thick-bedded white sandstones and conglomerates lie at the base of the limestone series, the pebbles of the conglomerates are almost exclusively composed of rolled vein quartz and quartzite, the latter having evidently been derived from beds of highly metamorphosed sandstone, probably of Cambrian or Lower Silurian age, while the vein quartz must have come from the fissures traversing these rocks. There is very little in the chemical composition of vein quartz rock to enable us to distinguish it from a highly metamorphosed sandstone or quartzite. In our purer sandstones, such as that of Craigleith, we find 98 per cent. of silica, and not much more is found in vein quartz. The points of difference lie then in the modes of occurrence.

As I stated before, all quartzites are only highly indurated sand beds, the siliceous grains of which were originally derived from igneous rocks, and vein quartz, in which the silica existed in a crystallized, or partly crystallized, condition. Vein quartz, and the quartz of granite and other igneous rocks, on the other hand, have been introduced into the cavities and fissures from silica held in solution, either in the original magma out of which these rocks were formed, or from highly heated waters which permeated them and filled the fissures wherever such existed. The silica, therefore, of quartzites, being a derivative material from older rocks, must always be more ancient than the strata of which it forms a component part, whilst that in the quartz of granite, and that found filling veins in the metamorphic rocks, is more recent in its formation than the strata which the granite erupts, or the vein quartz traverses.

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In Jukes' "Manual of Geology," 1857, p. 147, par. 60, quartz rock or quartzite is described as "a compact, fine-grained, but distinctly granular rock, very hard, frequently brittle, and often so divided by joints as to split into small angular, but more or less cuboidal, fragments. When examined by a lens, it may be seen to be made of grains, which appear sometimes as if they had been slightly fused together at their edges or surfaces, and sometimes as if embedded in a purely siliceous cement. This cementation or semi-fusion of the grains shows at once that it is a sandstone which has been altered, and indurated by the action either of heat alone or of heat and water. It has been *baked* or *steam-boiled*." In a foot-note it is further stated, "The student must carefully distinguish between quartz rock or quartzite, as here described, and pure *vein quartz*, which occurs sometimes, as a white, compact, flint rock, in considerable mass. The "quartz-rock" so often spoken of in Australia is rarely if ever true quartz rock, but is commonly vein quartz—a deposition in a vein or fissure produced subsequently to the consolidation of the rocks it traverses, not an altered bed of sandstone, contemporaneous with the rocks in which it lies." He further states—"The continental geologists seem frequently to fall into the same mistake and confound two things essentially distinct. In a collection of European rocks purchased lately from Krantz of Bonn—among seven specimens of so-called quartzite—at least five were undoubtedly *vein quartz* and not *quartzite*."

The purity of crystalline quartz depends on its freedom from mixture with metallic elements, its normal state, as seen in many of the quartz crystals from the Brazils, being as pure as the clearest spring water. The purple tint of the amethyst is believed to be due to the metal manganese, and the smoky brown of the cairngorm to titanium. Iron, copper, nickel and other metals also colour other varieties, and beds of sandstone known to have been deposited as a nearly white sand, are often found stained by oxides of iron and hydrocarbon elements, subsequently introduced by percolation through the strata. The white opacity seen in many pure quartz crystals, and in vein quartz, is found to be mainly due to two causes, viz., minute microscopic fissures, and fluid cavities. I formerly mentioned that if a crystal of pure transparent quartz be heated to redness, and then plunged into water, it will be found to have become white and opaque, and its structure traversed by in-

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numerable minute fissures—these being the chief cause of the opacity. Vein quartz since its formation has apparently often suffered from heating and cooling, it being generally very much fissured, and rendered still more opaque than would otherwise be the case by the multitude of minute cavities existing in its mass—due as previously stated to minute enclosures of fluid locked up in the quartz under enormous pressure whilst the silica was consolidating.

It might be asked, Why have not all quartz crystals these fluid cavities in their structure? The value of many Brazilian crystals, and of those used as gem-stones, is entirely due to the absence of these cavities, their presence depending entirely on the conditions of pressure and temperature at which the silica has crystallized. As I have said, silica is believed to have existed in the fluid state, in conjunction with water, at great depths in the earth's crust, and under great heat and pressure, and, after the associated minerals, with which it is now combined, were crystallized. I also mentioned that silica when combined with certain alkalies remains soluble in water after losing its heat, and that in this state, when the water is evaporated, it again becomes insoluble, and may be deposited in a crystalline or amorphous state according to conditions. I believe that these conditions explain the presence or absence in the quartz of fluid cavities, they being found in abundance in the quartz of granite, and in vein quartz, both of which are known to have consolidated under great heat and pressure. But with silica which has flowed upwards towards the surface, along with water from great depths, it would gradually lose its heat, and under the lessening pressure, all vapours would escape, and the silica would then crystallize without fluid cavities. According to the purity of the water of crystallization, and its freedom from metallic elements, so would be the purity and transparency of the quartz crystals formed. Such highly transparent crystals of quartz are generally found in druses or cavities of rocks which had previously cooled down to a normal temperature.

We find this same heat condition affecting the transparency of other minerals, amongst which I shall notice only the mineral calcite, under the beautiful form known as Iceland spar, which is calcite in its most transparent condition. It owes its transparency to the fact that the rocks in which it is found were never heated to

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any great extent after the crystallization of the calcite took place. If a bit of the Iceland spar is heated, it becomes, like quartz, white and opaque, and does not regain its transparency.

Silica exists largely in many of the other strata of the earth's crust in a condition quite distinct from the ordinary crystalline quartz. In the flint bands and nodules of the chalk, and in other calcareous strata, it has been derived from the waters holding it in solution. This silica, in the form of flints, generally contains a small percentage of iron, clay and lime, which have become mixed with the sediments. The secretion of the silica of flints is so often associated with the growth and the decay of organic matter, especially that of sponges, that the late Dr. Bowerbank surmised the geological office of the sponges in creation to be to induce the deposition of siliceous matter held in solution in the ocean, just as the corals assist in the consolidation of the calcareous matter. When lime, iron, clay, or other matter increases in any flint bed, the rock passes from the normal condition of flint, and is then known as chert or hornstone.

Floatstone, or spongiform quartz, another form of silica, is chiefly composed of the siliceous coverings of diatoms and other protozoan organisms. The analyses of some beds give 85·9 of silica, 0·7 of alumina, 9·1 carb. of lime, and 3·3 of water. Many of the beds are several feet thick, and are chiefly of lacustrine or fresh-water origin.

Igneous rocks in which silica abounds, either in a crystallized or combined state, are said to belong to the acid group. Those in which the silica is less, and seldom in a crystallized condition, are termed the basic group, from being composed of heavier mineral elements. Dr. Page, in explanation of the term, "acid group," as applied to the siliceous form of igneous rocks, says, "Although silica has none of the ordinary or more obvious acid properties, yet as it combines in definite proportion with many salifiable bases, and expels carbonic acid when fused with the carbonated alkalies, it is very commonly termed silicic acid, and its various compounds have been denominated silicates."

Very much more might be said regarding the many varied and interesting conditions in which silica or quartz presents itself to the mineralogist and geologist, as well as of its many industrial uses, about which much interesting information will be found in Dr. Page's "Economic Geology." In this work will be found

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noted the various building-stones in which quartz forms from a half to nearly the whole of the material, as in the granites, syenites, porphyries, felstones, greenstones, basalts, slates, schists, quartzites, and sandstones. For mechanical industrial purposes, we have quartz or silica, as the more important element in millstones, grindstones and cutting wheels, crushing and pulping wheels, polishing and cutting materials, whetstones, hones and burnishers. In the clays used for pottery and other industrial purposes silica is found, varying from 50 to 70 per cent. and upwards, and as much as 90 per cent., it is stated, is not at all incompatible with the formation of excellent bricks. In the gem-stones of the silica group proper we have the rock-crystal, amethyst, cairngorm, chalcedony, agate, onyx, carnelian, jasper, opal, etc., in all their varieties. And lastly, in the sands we vitrify, we find that silica lies at the foundation of all the great industries of glass-making, where ground flints and sands of various degrees of purity are used. For very pure glass crushed quartz or well-washed silver sand, free of iron and other mineral impurities, has to be employed, but for ordinary bottle-glass sea-sand is often preferred, as the lime, clay, and other admixtures it contains, increase its fusibility.

Dr. Page, remarking on the interest and value of the mineral and metallic products used in the industries of glass-making, says, "Thus one of the most beautiful and useful fabrics ever invented by man depends at once for its composition, its colour, transparency and other qualities, upon the mineral and metallic products of the rocky crust; and whether we regard the amount or variety produced—the opaque bottle, the transparent window pane, the shining mirror, the sparkling crystal, the coloured ornament, or the pellucid lens of the optician—there is no mastery of art over the crude materials of nature so decided and triumphant as that of the glass manufacturer."

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No. XXVIII.—Notes on the Heads of Ayr. By Walter Burns.

[Read 10th May, 1888.]

The cliffs known as "The Heads of Ayr" are about three miles south-west of the town of Ayr. The sections which I am about to describe are at Bourhill and Greenan Castle, both on the coast line, and the strata lying between these two points, the distance being about one mile. Bourhill, the highest point, is about 100 feet above sea-level. It is a mass of volcanic ash and agglomerate of a dark-green colour, and belongs to the Calciferous sandstone series. It appears to have been erupted subsequent to the deposition and solidification of the cement limestones, of which fragments are firmly embedded in the ash. It has also the appearance of bedding. If so, the eruptions of ash must have followed one another at very short intervals, as there appears to be no foreign matter between them. In the coast section are to be seen the same contemporaneous trap tuffs interbedded with the cement limestones.

The section on which Greenan Castle is built is of similar composition. As regards the dolerite dykes in this locality, there are six marked in the Geological Survey map, one of which, well exposed to view, and known as the "Deil's Dyke," can be traced more than a mile seaward at low water. They are apparently all of Miocene age.

The next group is the cement limestone series, also belonging to the Calciferous sandstones, which is well exposed between high and low water mark from Greenan to Bourhill. In the explanatory *Memoir* to accompany the Geological Survey map it is stated that "the series consists of numerous alternations of grey, green, and blue shales, argillaceous marls, white or grey sandstones, and ferruginous limestones or cement-stones. Some of the strata abound in organic remains, as cyprid cases, fish scales, and plants." The lie of the beds is at a very low angle, and the general dip is north-east. At Bourhill it is south-west, dipping under the hill; and a little to the S.E. the dip is north-west. The cause of these changes is, I think, due to the great amount of volcanic ash, of which Bourhill is composed, resting upon these beds. If they are continuous, and I observed no breaks, supposing the lowest to be at Bourhill and the highest at Greenan Castle, the depth would

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appear to be very great. The Geological Survey *Memoir* states that "a bore was put down through 330 feet without reaching the bottom at M'Nairston, five or six miles south-east of Ayr," so that in that locality also they appear to be of great thickness.

A most interesting section is the drift bed, which flanks the north-east side of Bourhill. It is a mere fragment, the length being about 30 yards and the depth at the thickest part not more than one or two feet, which thins away towards the east until it disappears. In a few remarks which I formerly made at a meeting of the Society on the occurrence of Chalk flints in this drift bed, and which are printed in the *Transactions* (vol. vi., p. 283), I am represented as having said that this bed was about 20 feet above high-water mark. What I really said, or ought to have said, was that the surface of the bank was about 20 feet at the highest point, and that the drift was from 15 to 16 feet above high-water mark. Since that time I have again gone over the ground, and I have found flints above the "Deil's Dyke," where I had a better opportunity of taking the correct height, which is between 9 and 10 feet. Remembering a statement by Mr. John Young, regarding the occurrence of flint nodules on this coast, that any one having an opportunity should be sure to make a search for flints in these beds, I began a careful inspection at the east end, but I had nearly reached the west end before I found one, and this I broke in two to find that it was a piece of pure chalk flint. I continued the search until ultimately I discovered about 20 nodules. As, so far as I am aware, there neither are, nor have been, flint-bearing strata in this locality, the questions arise—From what district did these flint nodules come, and by what agency were they transported? The same questions come up regarding the pebbles with which the flints are now associated, and which appear to be rolled fragments of rocks, probably belonging to the North-west of Scotland.

Looking from the Heads of Ayr across the Firth of Clyde towards Campbeltown, the thought presents itself that this channel may have been filled with glacier ice, and the more I have thought over it the more have I become convinced that such has been the case. Prof. A. C. Ramsay, in his "Physical Geology and Geography of Great Britain," p. 382, writes:—"Another part of the great glacier ice passed west across the Hebrides, and southerly into the Firth of Clyde, where, passing over Bute and

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smothering and smoothing those large mamillations, the Cumbraes, it was reinforced by the snows of Arran and buried that craggy ocean pyramid, Ailsa Craig." I believe that it was probably during the Great Ice Age that these rock specimens with their kindred boulders, seen lying on the shore, were deposited on the sea bottom, or what was formerly the sea bottom. I suppose it is now generally agreed that the Great Ice Age came on by slow degrees, and that it declined in the same manner; also that the land was submerged from one to two thousand feet. The length of time required Mr. Pengelly sets down, if I remember aright, at some 200,000 years. If so, the time between the deposition of the Scottish pebbles and the laying down of the Irish flints would appear to be many thousands of years. Probably the means of conveyance of the flints from the Irish to the Ayrshire coast was by floating ice. Let us suppose that a time had come when the channel was again comparatively free of ice, and that the land had risen to within 20 or 40 feet of its present level. The higher hills were probably still capped with snow, the glens filled with retiring glaciers, and during winter the shore was icebound. Some of us may have often observed in ponds in old quarries that the water, during a severe frost, is converted into ice. When the thaw comes, and the ice is broken up into fragments, the ice-foot is seen to be firmly packed with stones. In a similar way we should expect it to happen in shallow reaches on the sea coast, where the ice would reach the bottom and take up the pebbles into its foot. When the thaw came storms and tidal waves would break it up into masses, floating it hither and thither seaward. With a south-west wind blowing many of these would probably be floated from the North of Ireland right on to the Ayrshire coast, and there, melting away, the flints would be dropped on the sea bottom above the Boulder-clay. By some such means they may have been carried here and deposited. It will be observed that these flint nodules are of very small size, and there may be some difficulty in accounting for this, but one simple explanation is the long time they may have been subjected to rolling, and that the smallest were carried furthest.

Under what conditions was the bed of marine drift which contains the flints and rolled pebbles formed? The land was then probably from 20 to 40 feet below its present level, but it was still continuing to rise slowly, thus bringing the sea bottom more within the action of the tide, which would then wash and denude

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away the boulder drift, and as the sea gradually retired through the rising of the land it would heap up the gravel on the shore, and this action would continue until the land became stationary. In some such way, I think, this drift bed was probably formed, and the flints and pebbles re-deposited together at the same time. The water line would then be not less than from three to four miles further seaward than it now is, so that the site on which the town of Ayr is built must have been about that distance inland. It may also have been that during the last rising of the land, and after it became stationary, the mounds of blown sand, so abundant from Prestwick northwards along the ocast, were heaped up.

As the life of man is far too short for him to be able to observe great geological changes, he has therefore to be guided in a great measure by circumstantial evidence, and we have, I think, some such evidence at Greenan Castle. Any one now looking at it would never believe that this old fortress was originally built so near the edge of the cliff as it now stands, for it is impossible to walk round the outer wall, while the base of the cliff is cut inwards 4 or 5 feet further than its upper edge. As proof of its once farther extension, we are told that within the last 100 years a carriage could have been driven round the castle, but in a comparatively few more years at the present rate of denudation, we shall not be able to mark the spot where Greenan Castle stood.

The next point we may notice is how the bed of drift along the shore has been reduced. As soon as the land became stationary, the work of denudation would begin, and the sea having a more permanent face before it would begin to remove that which for so long a time it had been helping to build up. Every time I visit the Heads of Ayr I observe a change. Perhaps a piece of rock loosened, which, when I next look for it, may be broken up and washed away. The same thing happens with sand and gravel mounds. I was much struck at the state of matters three years ago when visiting this locality, especially the ground at the north-east side of Bourhill. On walking up to the former bed of drift, I found that instead of having to clamber up a height of several feet, it was not two feet above the level of the ground on which I stood, which I found to be some 6 or 7 feet higher than on my previous visit. Of the boulders, large and small, which were formerly to be seen by the thousand, there was now not one visible.

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A great part of the talus of the hill had apparently been washed away, and it appeared to be this material on which I was now standing. Going up to a cottage near the shore, I said to a woman who lived there, "You surely have had a severe storm here lately." "Yes," she replied, "it was last January, and the water was up as high as the door step." Then I recollected that a severe storm had at that time broken over the west coast, vessels being wrecked, and lives lost. A considerable portion of the sea-wall of the esplanade at Ayr was broken down, and the dyke of the Low Green was, if I remember rightly, entirely swept away.

On a later visit to Bourhill I noticed that the whole of the debris here mentioned had been again washed away, and that the boulders were exposed as formerly. I think it would be well if the members of the Society who have opportunity would take note of any such changes they may observe along our western coasts and report upon them. A series of such observations would be of great interest and value.

No. XXVIII.—Notes on the Scottish Carboniferous Genera of the Molluscan Family Anatinidæ. By John Young, F.G.S.

[Read 8th December, 1887.]

In the following notes, I intend to point out shortly some of the characters which distinguish the genera of the molluscan family Anatinidæ, found in our Carboniferous strata. As you are all aware, the various groups of organisms—plants and animals, fossil and recent—have been classified under the terms, kingdom, class, order, family, genus, and species, as here given, the grouping being determined from the points of external resemblance and internal structure in the organisms themselves. This arrangement enables botanists and zoologists to understand all the more clearly the various positions and relationships in both the vegetable and animal kingdoms. According to Woodward's "Manual of the Mollusca," the Anatinidæ belong to the Conchifera, the 5th class and 9th order of the Mollusca, and form the 19th family of its class. The Conchifera of Lamarck are likewise known as the Lamellibranchiata, which are further divided into two groups, viz., the Monomyaria, and Dimyaria, according to the number

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of muscular scars inside the shell, the Anatinidæ being placed with the latter.

The family of the Anatinidæ, or Lantern shells as they have been termed from their thinness and translucency, embraces several fossil genera found in strata belonging to the palæozoic, mesozoic, and cainozoic periods, and the family still continues to be represented in recent seas by several genera and species. So far as yet determined, there seem to have been no representatives of the true *Anatina* in Scottish Carboniferous deposits. Prof. M'Coy has, however, described two species from the Carboniferous limestone of Ireland, but Prof. Morris, in his "Catalogue of British Fossils," only admits them doubtfully into his list of the fossil *Anatina*. It is always very difficult with fossil species of the Conchifera to determine correctly the true relationship of the various genera to each other. This arises from our not being able in most cases to determine what are the internal characters on the interiors of the shells, and upon which their family and generic relationships often depend.

In Woodward's "Manual," the characters of the shells in the family Anatinidæ are briefly described as follows:—Shell often inequivalve, thin; interior nacreous; surface granular; ligament external, thin; cartilage internal, placed in corresponding pits, and furnished with a free ossicle; muscular impressions faint, the anterior elongated; pallial line usually sinuated." It is further stated, as in the case of *Pholadomya* and its fossil allies, that "the external surface of these shells is often rough with large calcareous cells, sometimes ranged in lines, and covered by the epidermis, the outer layer consists of polygonal cells, more or less sharply defined."

The following are the Scottish Carboniferous genera at present allocated with the Anatinidæ: *Myacites*, Brown, 1830; *Leptodomus*, M'Coy, 1844; *Sanguinolites*, M'Coy, 1844; *Edmondia*, de Koninck, 1844; and *Cardiomorpha*, de Koninck, 1847. These genera are all essentially marine, being found along with other marine shells in both the lower and upper limestone series, but as a rule they are more often found in the argillaceous beds of the limestone strata than in the limestones themselves. This mode of occurrence is also characteristic of nearly all the other genera of the Scottish lamellibranch mollusca, and has already been noted, when remarks were made on the group, in the "Catalogue of Western Scottish Fossils, 1876, p. 50." *Myacites*, the oldest of

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the Carboniferous genera, is represented in our strata by only one species, *M.* (*Hiatella*) *sulcata*, Flem. The genus *Allorisma* was subsequently formed for this and one or two allied species by Prof. King, in his "Monograph of Permian Fossils," but has not been generally accepted. Prof. M'Coy placed *Myacites* with *Sanguinolites*, but Prof. Morris has retained it as it was, in his "Catalogue of British Fossils," and as such the shell is best known to us. It has been found in several localities in the West of Scotland, chiefly in the lower limestone series, but as far as yet discovered, it seems to be nowhere common. When well preserved, the shell is seen to be very thin, a characteristic of the family, and some examples show the radiating lines of minute raised tubercles which give the surface of the shell its granulated appearance. Closely allied to *Myacites*, and sometimes placed with it is the genus *Leptodomus*, already mentioned. Woodward, in his "Manual," shortly defines its characters as, "Shell thin, ventricose, concentrically furrowed in front; escutcheon long and flat." M'Coy's description of the genus is much longer, but need not here be quoted, beyond the statement that "these fossils seem almost identical in form and thinness of the shell with *Myacites*," but he shows that it differs from it and the genus *Sanguinolites* in several external characters. M'Coy, in his "Palæozoic Fossils," describes seven species of *Leptodomus*, six from Silurian, and one, *L. costellatus*, from Carboniferous strata.

The type specimen figured by M'Coy is from Craigie, near Kilmarnock, where, he states, it is "common in the Carboniferous shales." He also records it "from Carboniferous shales near Glasgow," and "in the shale beds at Lowick, Northumberland." Since the period (1855) when M'Coy's description appeared, this shell has been found moderately common in several other localities in Western Scotland, but nowhere so abundant, of so large size, and in such fine preservation, as in the shale beds of the limestone series cut through this last summer at Girdie, on the new line of railway between Barrmill and Kilbirnie, Ayrshire. For a knowledge of this interesting locality for the shell under notice, we are indebted to our esteemed corresponding member, Mr. Robert Craig, Langside, Beith, who has diligently collected the fossils in these shale beds, and who last summer guided a joint excursion of the Edinburgh and Glasgow Geological Societies to the locality. Mr. Craig has been collecting notes on the strata

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exposed along this new line of railway for some time, and I hope, when these are completed, that he will present the Society with an account of what he has observed, with a list of the fossils.

I may here mention that M'Coy's type specimen of *L. costellatus*, from Craigie, is given as one inch five lines in length, but those from the Beith railway cutting that I have measured are two inches one line in length, and proportionally as large in every other direction. They were found in nearly every instance with their valves united, and very seldom much crushed. The evidence from this and the other localities where this shell has been found is that this species burrowed in the mud; hence after death their fragile shells would remain in the sediments, and so not be nearly so liable to be broken or scattered about by the sea waves. The state of preservation of the shells in this locality not only shows that the interior layer was nacreous, but that the middle layer has a minute acicular structure, and the outer layer a coarse structure with large calcareous cells. These characters are all well seen in sections of the shell that I have prepared for examination under the microscope. In other localities the shell has generally not been so well preserved, being in some instances pyritized.

The genera *Sanguinolites*, M'Coy, and *Edmondia*, de Koninck, seem both to have been established in the same year (1844), and are held by some palæontologists to be so closely related in their characters as to be identical. Woodward in his "Manual" unites *Sanguinolites* with *Edmondia*, and gives the following as the generic characters:—"Shell oblong, equivalve, thin, concentrically striated, close; umbones, anterior; ligamental groves, narrow, external; hinge-line thin, edentulous, furnished with large oblique cartilage plates, placed beneath the umbones, and leaving space for an ossicle? pallial line simple?"

At present both the genera are admitted into the lists of Carboniferous fossils, the species with the longer form of shell being placed with *Sanguinolites*, and the shorter forms with *Edmondia*. In the "Catalogue of Western Scottish Fossils" no less than nine species of *Sanguinolites* and nine species of *Edmondia* are noted from various localities and collections, but I am very much inclined to think that several of the species there given are due to faulty determinations, and that we have not more than half the number stated. I also now know that one or two of the forms hitherto placed with the above genera do not belong to the family of the

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Anatinidæ, and will have to be placed elsewhere amongst the Conchifera.

The species of *Sanguinolites* and *Edmondia* found in Scottish Carboniferous strata range from the marine beds of the lower limestone series into those of the upper limestone, but are chiefly found in the shale beds. Their habit of life seems to have been very much akin to that mentioned in connection with *Leptodomus*, their shells also being generally found with the valves united, indicating the conditions under which they lived. In illustration of this point, I may mention that in the thin band of impure cement limestone found at Bishopbriggs quarries, north of Glasgow, the fine specimens of *Edmondia sulcata*, Phill., there obtained were generally found with their valves united, standing in their natural vertical, burrowing position in the sediment. In this same stratum the shells of *Pinna flabelliformis*, Mart., were also found standing erect, and with their valves united, showing that the palæozoic species were, like their modern representatives, burrowers in the sediments where they lived.

The next form to be noted is the genus *Cardiomorpha*, de Koninck. Woodward, in his "Manual," admits it somewhat doubtfully amongst the Anatinidæ, and briefly describes its character as follows :—"Shell Isocardia-shaped, smooth or concentrically furrowed, umbones prominent, hinge edentulous; hinge-margin with a narrow ligamental furrow, and an obscure internal cartilage groove." M'Coy, "Palæozoic Fossils," p. 509, also remarks on the genus, stating that the shells of *Cardiomorpha* are very thin, resembling the recent *Isocardia* exactly in form, but perfectly distinguished by want of teeth; which character, and the inflection of the cardinal margin, approximate the genus to *Leptodomus*, M'Coy, from which they differ by their large inrolled beaks and closed margins, without byssal furrow, etc. From the extreme thinness of the shell the muscular and pallial scars are rarely visible.

In the "Catalogue of Western Scottish Fossils" seven species of *Cardiomorpha* are noted from the Carboniferous limestone strata. Several of these are very rare, and one or two appear to be doubtful identifications. The most common species, although still a rare shell, is *C. oblonga*, Sow., found in both the lower and upper limestone series in several localities. None of the species of the genus found in our beds seem to have reached the size of those obtained from the English and Irish limestone strata. Those I exhibit are

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from the Robroyston limestone series, north of Glasgow, and are the largest and finest I have yet obtained.

I have only one other Carboniferous genus to notice, one which has provisionally found a place amongst the Anatinidæ, and of which two species are stated to have been found in Scottish Carboniferous strata. This is *Sedgwickia*, M'Coy. Woodward in his "Manual" makes it, however, to be only a sub-genus of *Myacites*. The shells of the species of *Sedgwickia*, are, in general, of small size. M'Coy in describing their generic characters, says, "Shells equivalved, or nearly so, inequilateral; shell very thin, inflated; dorsal and ventral margins subparallel; anterior half of each valve marked with strong, transverse ridges; posterior half smooth; beaks moderate; anterior side very short, round; posterior side broad, lengthened, subtruncate." He further says, "These beautiful shells are remarkable for having the anterior half of their valves marked with strong, transverse ridges, and the posterior half perfectly smooth." I may here state, that the genus *Sedgwickia*, so far as known to me, has not yet been recorded from the Carboniferous strata of western Scotland, and I only notice it here, because Mr. Robert Etheridge, sen., in his Presidential Address to the Geological Society of London, *Quarterly Journal*, vol. xxxvii., p. 219 (1881), gives a table of "18 of the chief Dimyarian genera" found in England, Scotland and Ireland, and in that table Scotland is credited with 2 species of *Sedgwickia*, and Ireland with 7 species, none being found in English Carboniferous strata. It is not stated in what district of Scotland these specimens were obtained, nor from what horizon of strata. If the genus has been correctly identified the specimens are probably from some of the eastern districts, as it is not recorded in the "Catalogue of Western Scottish Fossils." Neither can I find it amongst the numerous lists of fossils given by the Geological Survey in their *Memoirs* explanatory of the geological maps of the western coalfields.

In bringing these remarks to a conclusion, I have only further to state, that a great deal of investigation still requires to be made into the group of shells forming the Conchifera, or lamellibranchiate mollusca, of the Carboniferous period, before we can arrive either at their numbers or true relationship to each other. In the address of Mr. Etheridge already referred to, he states, p. 217, that the united British Carboniferous Lamellibranchiata, forming the

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two divisions Monomyaria and Dimyaria, number 54 genera and 424 species. I am quite certain that in the hands of any specialist these figures would be very much reduced, especially as regards the number of species in several of the genera. The case here is very much the same as that which the late Dr. Davidson found amongst the Carboniferous Brachiopoda when he took up that group for investigation, as already recorded in a former paper to the Society by myself ("Notes on the Carboniferous Brachiopoda of Scotland," *Transactions*, vol. viii., p. 144). It is there stated that Dr. Davidson found that then no less than 260 so-termed species had been named and recorded by various palæontologists from the Carboniferous strata of Britain and Ireland; but that he, after labouring amongst the group for a long series of years, and assembling specimens from all the collections to which access could be obtained, decided, after a most searching investigation, he could not admit more than about 100 of these into his list, and that amongst these there were still some doubtful forms which were probably only varieties.

If such has been found to be the case with the Carboniferous Brachiopoda, which possess better marked internal and external characters than many of the Carboniferous Conchifera, we may, as already stated, expect a great reduction of the number of so-termed species of this group when they come to be carefully examined. As a case in point, I may mention that Mr. Etheridge, in his "Address" quoted above, states that 150 species of the genus *Aviculopecten* are found in the Carboniferous strata of Great Britain and Ireland, including 50 from Scotland. I have good reasons for believing that this is far beyond the number of species in the genus. I also know that, in several instances, species in this genus have been founded on the differences existing in the ornamentation of the opposite valves of the same shell, these being generally in a disunited state when found. Differences in the conditions of growth over the old sea bottom, and in the nature of the sediments in various localities, as well as the existing state of preservation of the shells themselves, have, either singly or combined, produced variations in the same species, which in the hands of different palæontologists have caused their erection into new species. What I have here stated regarding *Aviculopecten* might also be urged against many of the other genera of the fossil Conchifera. There seems in the past to have been too great a desire to make new species, and we wait for the

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time when some specialist will do for the Lamellibranchiata what the late Dr. Davidson so ably did for the Brachiopoda, bringing the group out of confusion both as to genera and species, and thereby enabling students of the mollusca to form a fuller and clearer conception of an interesting class of organisms, which formerly, no doubt, played an important part in the world's life-history.

No. XXX.—The Redemption of Sandstone Quarries. By James Bennie, of the Geological Survey of Scotland.

[Read 31st May, 1888.]

I shall perhaps most fitly introduce the subject of this paper with a reminiscence. At an early time in my pursuit of fossils, I was attracted to the shale heaps in limestone quarries as giving the most congenial opportunities for collecting. This was due to the fact that neither crowbar, pickaxe, nor shovel, nor even hammer was required to resurrectionize the remains of the long-past dead that I coveted, this having been already done by the hands of the quarrymen, helped by the disintegrating influences of the weather. All that I had to do was simply to kneel down on the weathered shale heaps, and lift the fossils as easily as is done in gathering shells from the sands on the seashore. For many years, I therefore haunted all the shale-bearing quarries within an easy walk or railway ride from Glasgow. The yield of fossils was great at first, especially in the shale heaps I was the first to discover and search, and for a long period I had full occupation for all my holidays. By-and-bye, however, as the time rolled on, the field became exhausted, first of the rarer fossils and then of the more common species, till at length the crop did not repay the trouble of gathering, and for a whole year the only outlet I could get for my leisure time was to ramble in search of the picturesque and the beautiful in scenery. But I well remember how little I was pleased with the change, and how I sighed for new ground which had not yet been searched by fossil-hunters like myself. Fortunately, this interregnum lasted only for a short time, and by a new revelation of hitherto unsuspected ways and means of getting

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undreamed-of fossils in the old shale heaps, my interest in them was revived and intensified. This was caused by learning, chiefly from Mr. John Young, that by taking weathered shale exhausted of its larger fossils, and washing it, thousands of smaller organisms could be found in the residuum. These minute fossils being new to me by sight, and some even by name and nature, all the quarries which contained shale which could be washed, were re-visited with increased zest and greater frequency, as there was no chance for many long years of the shale being exhausted of their minuter forms; and Orchard, Robroyston, Blantyre, and Kilbride became again the favourite goals of my geological rambles.

What happened many years ago with shale-yielding quarries has lately taken place in my experience with sandstone quarries. In the course of some researches which were made in quest of beds containing spores, I have found that many old sandstone quarries, from which nothing has ever been got since they ceased to be worked, have yet in their waste heaps materials which have yielded fossils previously unknown in such places, and which have opened up to the mind scenes and incidents unthought-of in such connections, thereby imparting a new interest to them which amounts to their complete redemption from the barrenness to which they had been consigned. Thinking that the members of the Geological Society of Glasgow, who, like the ancient Athenians, have always been famous for seeking after new things, might take an interest in what I have to say upon this subject, I have brought this paper before them to-night.

In the paper "On the occurrence of spores in the Carboniferous Formation of Scotland" (*Proc. Roy. Phys. Soc. Edin.*, vol. ix., p. 82), there is an allusion to spores having been found in Hailes quarry, in the partings of carbonaceous matter in certain fakey layers in the sandstone, and the suggestion is made that all the black streaks and blacker laminæ which so distinctively characterize this sandstone were probably made up, chiefly, if not wholly, of spores, sacs, and fragments of wood, which had been floated by streams, or wafted by winds, into the lake in which the 200 feet of rock were formed. Also that among these vegetable waifs of land or water were frequently found fragmentary remains of animals, such as scorpions and eurypterids, which had, of course, been carried into the lake from the land by similar agencies, and deposited like the spores and sacs. In the same

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paper, in the list of localities where spores were found, Joppa quarry was noted as having spores in black fakes in its eastern face. Since the paper was published I have pursued the same line of research, and have found many instances where black fakes have yielded in great abundance the same objects as in Hailes. Perhaps, however, the best examples are those of Kingscavel Quarry, near Linlithgow, and South Coltpark, near Bishopbriggs, both of which are notable instances of how "the Redemption of Sandstone Quarries" has been effected by the search for spores, and how they have been thereby saved from being given over finally to the "abomination of desolation."

The workings at Kingscavel quarry, from which the stones of the palaces and towers of Linlithgow, the "ancient Windsor of Scotland" as Lord Rosebery called it, were derived, having been discontinued for 15 or 20 years, there was no hope of any fossils being got from the beds, and the fossil-seeker going into it, and seeing only waste heaps of broken sandstone or bings of useless fakes, might in his chagrin curse it with the curse of the barren fig tree, and turn from it with contempt and disgust, as I myself would, a few years ago, have done with emphasis. But having learned from Hailes that more was to be had in fakes than met the uninformed eye, I was greatly delighted on my first visit to Kingscavel two years ago (1886), to see a great depth of rock composed of black fakes, and still more pleased to find that much of these fakes had been lifted and stored up in the quarry, as if purposely for my special benefit, when circumstances had taught me their value, and how to put them to palæontological use.

The section in Kingscavel is, in descending order, as follows:—12 feet or so of blue earthy shale with ironstone ribs and nodules, 12 feet or so of amorphous sandstone, 2 feet of soft shale with 8 inches of good coal, 30 feet of sandstone, and beneath it several feet of black and white fakes. In the undersoil, beneath the 8 inches of coal, spores, scorpions' skin, and the usual vegetable *debris* were found. Through the bottom beds of black fakes a tunnel had been driven for a quarter of a mile or so, and a tram rail laid to the canal bank, perhaps half a mile. The fakes have been piled up or built into walls to support the heaps of *debris*, and keep them from falling down and blocking the cart-ways from the working face to the tunnel. These fakes when quarried had been firm and compact, and therefore fit for building into these

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walls, but the weather had rendered them soft and loose; they could therefore be easily cut into with my trowel and crushed by the hand in water, and thereby be made to disintegrate into their individual parts, so that their characters could be determined with ease and precision. But this disintegration was not universal, as much of the vegetable *debris* having fermented in the process of mineralization had been converted into bitumen, which, acting as a cement, prevented most of the spores from being individualized. Again, the spores having been much compressed, they became thin and mere scale-like films, all the soft substance having been squeezed out of them, with only the skin left behind. Again, they were so often fretted and rubbed by the grains of sand upon and among which they lay, that they were not so robust in body or even so smooth-skinned as those which are embedded in soft clay or shale. Still many escaped unhurt, and are so perfect in appearance as to enable us to realize them as they were in life, or early after death. Besides the sacs and spores were many bits of scorpion and eurypterid skin, quite distinguishable as such by the ornamentation embossed or inserted into their substance.

On my visits it was very pleasant to sit and lunch in Kingscavel; the high walls of rock on every side made it "lown," while its width allowed the sun to light it up clearly or brilliantly. Some four or five years previously it had been planted all over with young firs and other trees, which having grown a foot or two high looked very beautiful, the dark-leaved spruce or Scotch firs contrasting finely with the light yellow green of the larch and beech. Another circumstance which added much to the pleasure I had in searching the washed results of my gatherings was due to the fact that many fragments of recent insects and flies were mixed with the fakes, and turned up frequently to the eye, as I scanned the material scattered on the slate to be searched. Every now and then a spore or a thistle seed, a sac or a withered leaf, a bit of scorpion skin or the wing case of a beetle, a bit of eurypterid skin or the head, or eye, or wing of a fly, or portion of a spider appeared. The past life of the Carboniferous time thus intermingled with that of the present suggested many thoughts and fancies which made the search a pleasure and a delight. The cause of this interpenetration of the present into the past was doubtless due to the fact that the wall of fakes stood in the quarry facing the sun, and the flies and insects which love to bask

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in its rays frequented these nooks and crannies in preference to the more shady corners. The spiders and other predatory creatures would then instinctively hunt or spread their webs where the prey abounded, and having eaten the soft parts, or sucked the vital juices, the wings and harder portions would be left lying about, so that when my resurrectionary trowel lifted the long-forgotten relics of the past, it also lifted the *disjecta membra* of the recent dead, and consigned them to one common inspection under my lens. This constant turning up of recent beetle or fly remains made the absence of ancient insects among the fossil dust more remarkable, and added another why and wherefore to the many that have been asked, Where have all the remains of Carboniferous insects gone that never one turns up amongst the remains of the creatures that preyed upon them? As in the hyenas' dens of the interglacial caves the gnawed bones of their victims are found, so here we ought to find the wing-cases or wing-membranes of the creatures that the scorpions and eurypterids stung and sucked to death. The beetle cases are surely as indestructible as the skin of scorpions, and should have remained as undecayed and have been as readily found and recognized.

The underclay of the small coal in Kingscavel quarry yielded many spores and some bits of scorpion skin, but the coal itself was pure bitumen or mineral carbon, and contained nothing organic. Everything having life in it had gone to pot literally, and had been melted into bitumen, that old world churchyard adipocere, blacker than pitch, and quite as oblivious of what it once had been. The spores were different from those in the fakes, and sparser, being only those that had been buried where they lived and died; whereas those in the fakes had been gathered from a large area by streams or winds, and huddled into a common tomb.

The next quarry to which I shall refer as a notable instance of how interest in it was revived, nay, I may say, created, by black fakes and what was found in them, is South Coltpark quarry, Bishopbriggs. My recent acquaintance with it arose from a paper by Dr. Young and Mr. John Young, read before this Society (see *Transactions*, vol. ii., p. 283), in which it is stated that strata, composed of thin layers in which much vegetable matter was visible, occurred, and from this fact I thought there might be some good fakes in it. I found the quarry situated on the north side of Colston Road, between the highway from Glasgow to Bishopbriggs

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and Fernbank House, and consisting of a large open square formed by heaps of rubble stone on the north and south, a high wall of solid sandstone on the east, and on the west by the old waste heaps of North Coltpark quarry, which were, however, divided from it by the North British Railway. The bottom of the quarry was covered by grass and a shallow pool of water lay under the east face. At first sight the chance of fossils of any kind even in black fakes seemed hopeless, as there were no bings of such as I had hoped there might be from the descriptions given by the authors of the paper already quoted. I saw only heaps of broken sandstone, quite amorphous, and sorely blackened with smoke dust. On the north side some bings of yellow weathered blocks proved that the cement-stone occurred in this quarry as in all the other quarries of Bishopbriggs, and looking across to the top of the thick sandstone, it was seen stretching all along the east face as a dark band some 12 or 14 inches in thickness. Wishing to have a closer look I crossed to the S.E. corner in order to climb up to it. In doing so I came to a wall of sandstone blocks built up against the rubble heaps to keep them from sliding down upon the men when at work. Looking at this wall I saw that many blocks of fakes had been built into it, and on examination found them to be black fakes so thoroughly weathered that large portions could be easily cut out with a trowel. Many had crumbled into dust, but others had only got the stoniness rotted out of them, and still adhered as bundles of laminæ, black and white alternately, in regular "Sunday-stone" fashion. These fakes were to the eye more grey than black from being highly charged with sulphur, which in weathering had turned into a grey dust which gave to even the blackest of the fakes so disreputable an appearance that at first I was rather doubtful of their good character. Having formerly got good things from sulphur-dusted material, I took two large bags of these fakes. These on being washed and examined turned out so good that I went three times afterwards for more, and brought away each time as much as I could carry, Atlas-like, on my back.

The yield in vegetable *debris* was chiefly in sacs which were innumerable, ranging from mere dots to some half an inch in length and about quarter an inch in breadth. Some were circular, others elliptical simple ovals, while a few were lanceolate. Most of them were quite free from carbonaceous matter, and translucent, letting the light shine through as if they were slightly tinted glass. Some

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were very thin, mere films, while others were dense and dark-red, through which the light came darkly. These sacs are supposed by Mr. Kidston to be the bags which contained the microspores of lycopods such as *Lepidodendron*. The next most interesting vegetable remains were fragments of the epidermal tissue of plants, with dark and light stripes, or bars arranged lengthwise, and in the light spaces were rows of holes similar to those Mr. Kidston has stated to be the stomata or breathing pores of plants. There were also some very thin tissues, the true character of which could not be made out, but which were supposed to be skins of fruits like nuts, or *Cardiocarpi*. There were also, but only very few, bits of pinnæ of ferns completely mummified; carbonized wood was rare and only in crumbs.

Spores were not nearly so numerous in Coltpark as the sacs; still they were in considerable numbers. Some few were large with the surface sparsely pustulated; these were true *Triletes*: others covered with hairs and, having ears, were true *Lagenicula*. This was the most abundant form, and generally they were in good preservation. Mr. Kidston has made out four species of *Triletes* from South Coltpark—*Triletes* II., III., VI., IX.—and one species of *Lagenicula* and variety—*Lagenicula* I., and var. *major*. Descriptions and figures of these spores will be found in the paper "On Spores" (*Proc. Roy. Phys. Soc. Edin.*, vol. ix., p. 82).

The animal remains were superabundant and good, scorpion skin being in comparatively large pieces. Many of these were finely perforated with holes, or rather pores, some being scattered promiscuously, while others were in rows. Some had raised bosses which were darker than the main body of the skin; others had nicked or vandyked edges with raised margins probably the edges of carapaces or segments. Several ribbon-like bits which were evidently fragments of limbs were double with a thickened selvage. One of these had a single row of pores throughout the centre, length-ways, but none at the side, as in most others. Some fragments had wide holes like a piece of perforated zinc, the space occupied by the pores being equal to the solid interstices. Very few bits of eurypterid skin were found—just enough to say they occurred. Sometimes I thought I had got other animal remains, but I never could make certain of any, and had to let them pass with a point of interrogation attached in my memory.

I then tried to fix the place of the fakes in the section. It

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was clear they could not have come from the position of those described by Dr. Young and Mr. Young, as they were said to lie below the sandstone wrought at South Coltpark, and therefore could not be touched in working it, and the 40 feet bed of sandstone exposed was solid throughout. They must be sought for above it, and on climbing to the top I found, beneath the cement-stone, a layer about a foot in thickness of black and white fakes, which, I thought, if weathered like those I got in the wall, would yield the same fossils. On taking a sample and proving it, I did not, however, get the same results or indeed anything tangible, as they broke into black and white grains. Still I think that the black fakes in the wall came from the same bed, but at parts where the vegetable and animal remains were less comminuted, and where they were laid down in more continuous layers, so that on weathering they came out whole as when deposited. The sand-stone here exposed is the same bed as that wrought in Crowhill, Huntershill, Kenmure, and North Coltpark, with the cement-stone lying on top of it in them all. As Crowhill and Huntershill quarries are on a higher level than South and North Coltpark, a fault is said by Dr. Young and Mr. Young to exist between them, and Mr. Hull has mapped it, but he seems not to have noticed the cement-stone in South Coltpark, as no blue line is laid down for it. I proved the existence of the cement-stone in South Coltpark by tapping it with my hammer in places there, while in North Coltpark it was in course of being lifted, and I walked over the top of it to examine the overlying shale. As the cement-stone of Bishopbriggs is without doubt the equivalent of Orchard Limestone, the fakes below it must be paralleled with the coal 18 inches in thickness below that limestone; and thus we have the same vegetable remains turned by dissimilar conditions into black fakes in the one case and into coal in the other, the presence of sand and mud or their absence making the difference between fakes and coal.

In the quarries hitherto cited the redemption has been due to black fakes occurring in thin layers of sandstone, but in some quarries the black fakes are intercalated in beds of blaes which, when thrown aside as waste, weather down to dust, and can be gathered and treated in the same way as limestone shale. The specimens of spores or animal skin got from blaes are generally in better condition than those from sandy fakes, as the sand grains or the mica flakes damage them by minute pitting through pressure.

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Every bed or heap of blaes in any sandstone quarry ought therefore to be tested for spores. To show this by example, I may briefly quote two instances known to me. In Whinnyhall quarry, a mile N.E. of Burntisland, under about 40 feet of coarse, barren sandstone, occur 12 to 14 feet of layers of sandstone, each from 2 to 3 inches in thickness, and divided by partings of blaes from mere films to an inch or so in thickness. These which are shovelled aside weather readily, and have yielded many spores and pieces of scorpion skin in much better condition than those from the sandy fakes of Hailes or Kingscavel. In Gilmerton sandstone quarry there also occur two beds of blaes between the sandstone which have yielded great numbers of spores, sacs, and pieces of scorpion and eurypterid skin, in an equally good condition, and these have placed the sandstone of Gilmerton higher in my regard as a good hunting ground for fossils than the shale of the Gilmerton limestone is now or ever has been in my acquaintance with it.

The redemption of sandstone quarries has not come solely from black fakes, but also from the small coal seams sometimes exposed in them. One of these small coals occurring in Kingscavel quarry would, of itself, have been enough to have taken away the reproach of barrenness from it, if indeed the coal had not been quite outdone in that way by the fakes. Crowhill quarry, at the northern end of Huntershill, and a little N.E. of South Coltpark, has, in strata which lie above the cement-stone, two small coal seams which are separated from each other by 4 or 5 feet of shale or blaes. The lower of these coals is 2½ inches, and the upper perhaps double that, in thickness. Under the lower seam are 2 inches of a hard earthy clay, so highly charged with sulphur that it is quite white, and full of small hairy spores of the kind styled by Mr. Kidston *Lagenicula* I. Under the upper coal seam there is also a layer of earthy clay in which the spores are more numerous and of a larger kind. It was rather difficult to cut out the lower clay, as I had to knock off the coal from above it with my hammer, and then cut it out in crumbs with my trowel. Further to the southward it was, however, much softer, and samples were got more freely.

Such are the facts which I think fully justify the title of this paper, and if any of my hearers agree with me that they in a geological sense redeem the quarries in which the fossils just described occur, I trust they will follow my example, and go and do likewise with the sandstone quarries throughout the district of

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which this Society takes more special cognisance. And if such is done, I can safely promise that in the doing of it they will have much pleasure and a great reward. They will be led into places such as I have described Kingscavel to be, and will derive therefrom scenes and legends of the present and past life of the earth, which will make it seem dearer to heart and mind than ever before, and they will find objects which will stir the imagination into renewed vigour, and enable it to body forth and give a "local habitation and a name" to things hitherto undreamt-of in their philosophy. While handling the spores and sacs or other relics of this old-world vegetation, they will conjure up glimpses of quiet forests, of stately and ornate trees of *Sigillariæ* or *Lepidodendra*, crowded with cones from which, as the winds ruffle the branches, the spores would scatter forth to replenish the earth with trees after their kind as long as Nature has need of them, and that with a profusion that makes sure that though "of fifty seeds she often brings but one to bear," care has been taken that the one shall always be forthcoming, and that the remainder shall not all go as "rubbish to the void," but be carefully gathered up into fakes or shales to furnish us with the pleasure and profit of studying such old-world remains, or into spore coal to supplement the sun when in these latter days by reason of old age he cannot give us the heat and light he formerly used to do!

Further, as the fragments of scorpion or eurypterid skin turn up to the bodily eye, among the crowd of mummified spores or sacs, the mind's eye will forthwith see scorpion-like creatures going about the roots of these same *Sigillariæ* or *Lepidodendra*, seeking and doubtless finding among the castaway spores and sacs, or beneath the dropt cones, or fallen fern fronds, other creeping creatures which they can catch, and sting, and devour, by the same means and with the same zest as their kindred do at the present time. Imagination fails us in that it cannot yet shadow forth the forms thus caught and forced into the service of a higher life than their own—those creatures, the true insects of the Carboniferous period in Scotland, of which at present we know nothing more than that they must have been—but their remains may yet be found if diligently sought for in the shales, or plant beds, where the fragments of the scorpions and eurypterids which preyed upon them so much abound.

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No. XXXI.—Notice of the Late Professor de Koninck, *Honorary Member*. By James Thomson, F.G.S.

Laurent-Guillaume de Koninck, doctor in medicine, and Professor of the University of Liège, a most distinguished palæontologist, and an eminent chemist, was born at Louvain in Belgium, on 3rd May, 1809, and, entering the University of his native town, studied for the medical profession. On the completion of his curriculum, at an early age, he took the degree of doctor in medicine, with honours in other departments of scientific inquiry. In 1834 his eminence as a student attracted the attention of the Government, and, in order that he might travel and acquire a knowledge of chemistry in other countries, he was at its expense sent to travel. At Paris he then studied in the laboratories of Gay-Lussac and Thenard, at Berlin with Mitscherlich, and with Baron de Liebig at Giessen. In 1835 he was elected a fellow of the University of Ghent, and placed in charge of the course of industrial chemistry. His removal to Liège towards the end of the following year was at his own request, and there he taught organic chemistry. In December of the same year the Royal Academy of Sciences of Belgium elected him a corresponding member, his nomination as member dating from 1842. Though he worked assiduously, both as student and as teacher of chemistry, and made some important discoveries in that department of science, he found time in the intervals between his numerous duties to study the Carboniferous fauna of Belgium. He was a close observer, a careful collector, and a painstaking note-taker, the most minute differences in structural details being carefully examined and recorded.

With that eminently characteristic industry which distinguished him throughout his long and honourable career, he soon acquired sufficient data to warrant the issue of his first palæontological paper in 1837. Amongst his numerous contributions to science, both chemical and palæontological, his well-known "Descriptions des Animaux Fossiles qui se trouvent dans le Terrain Carbonifère de Belgique," in two volumes, with a supplement, which appeared between the years 1842 and 1851, is indispensable to the student of the fauna of the Carboniferous system.

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His fame became more widely known, both as a chemist and as a palæontologist, inducing not only his own countrymen, but also those of other nations to confer upon him numerous honours. In 1846 he was elected Knight of the Legion of Honour, and in 1852 had the order of Leopold conferred upon him, also the order of the Red Eagle of Prussia. As a mark of their appreciation of his researches, the Kings of Prussia and Italy awarded him their great gold medals for his important scientific works, honours awarded only to the most distinguished scientific men. In 1853 he was awarded the Wollaston Fund to aid him in his important researches, and in the same year he was elected one of the Foreign Members of the Geological Society of London. Professor de Koninck was member, or corresponding member, of numerous learned societies; amongst others—the Academy of Medicine of Belgium; the Academy of Sciences of Turin and of Munich; the Geological Societies of London, Berlin, and Dublin; the Philomathic Society of Paris; the Imperial Society of Naturalists of Moscow; the Imperial Mineralogical Society of St. Petersburg; the Dutch Society of Sciences of Haarlem; the American Philosophical Society of Philadelphia, etc., etc. On several occasions he was selected by the Belgian Government to adjudicate on the merits of competitors for scientific honours, and in 1862 he was delegated to report on the chemical products exhibited at the International Exhibition of that year in London.

Professor de Koninck's first publication appeared in 1833, when he was comparatively a young man, and during the intervening period till 1887 he issued not less than from sixty to seventy separate memoirs, some of which were exhaustive and extensive in their character, and, bearing the imprint of originality and care, became indispensable adjuncts to the working palæontologist. But he did not live to finish his colossal work on the fauna of the Carboniferous Limestone of Belgium, which was intended to be a summary of all his investigations of the fauna of that system. He had completed the descriptions of the fishes, the cephalopoda, the gasteropoda, and the lamellibranchiata, forming volumes 2, 5, 6, 8, and 11. The volume containing descriptions of the brachiopoda was also nearly completed. In the last letter I had the honour of receiving from him shortly before his lamented death, he feelingly refers to his continued illness from brain fever, and his inability to continue his investigations; and he pathetically states that he had

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only twenty-seven species of brachiopoda to describe, to complete his memoir of that group. Had he lived to finish this great work, it would have been (and is, so far as it goes) the most exhaustive palæontological treatise that has ever been issued. Even in its fragmentary state it places the author in the eminent position of ranking with his late, and often referred to, friends, Professor Louis Agassiz and Dr. Thomas Davidson, F.R.S.

The memoir by Professor de Koninck on the corals of the Carboniferous System, 1872, "Recherches sur les animaux fossiles du Terrain Carbonifère de la Belgique," is an important addition to the knowledge of that group of fossil remains, and bears the impress of careful work. His additions to our knowledge of the simpler groups, notably the genera *Amplexus* and *Zaphrentis*, are invaluable to the student of corals. Had he lived to overtake a general review of the corals he would have made some alterations, arising from a careful examination of sectioned forms which he made when visiting the writer in 1877. After examining the structural details of the genus *Amplexus*, and the nearly related *Caleophyllum* of Dana, and their merging into the genus *Campophyllum*, he was persuaded that the line of demarcation was extremely minute, and could only be determined by the thorough examination of sectioned specimens. This led to his types of fossil corals being sent to me for comparison and identification with our Scotch specimens. The result enabled us to identify a number of species, and, if he had lived, would have resulted in a more intimate relationship to revise and complete the classification of the group.

Our deceased honorary member was alike distinguished by his scholarly attainments, purity of motives, and transparency of character. Information received, even from the humblest source, was not only gratefully acknowledged, but found a place in his masterly works. In the long and pleasant correspondence with which I was honoured, there were frequent references to even the most trifling information received from his numerous correspondents. His intense desire to add something new had no influence in inducing him to withhold honourable mention of the discoverer, as is sometimes done. He, like his late friends, Louis Agassiz and Thomas Davidson and many such eminent scientific workers, had been often indebted to the provincial and practical field workers, and with all such men the recording of discoveries, no

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matter by whom they are made, finds a prominent place in their published works. From the sagacity displayed in the definition and arrangement of genera and species in his great work already referred to, which appeared in 1842 and 1851, Professor de Koninck's reputation rapidly spread to such a degree that fossils were sent him for identification from all parts of the world, and his careful examination of the most minute details, and comparison with examples from other countries, enabled him to identify forms with a wonderful degree of certainty. Thus the fame of his careful work not only added to his own reputation, but also aided all palæontologists, wherever they might be located, to identify genera and species with great certainty. As in all human work, there will be doubtless modifications of and additions to his colossal labours, but arising principally from the imperfect geological record. New forms will be discovered, and new facts revealed, which will necessitate a re-arrangement of the greatest author's works. Yet what Professor de Koninck has left as his contribution to the cairn of intellectuality is, and will continue to be, regarded as a never-dying tribute to his world-wide fame. The Council of the Geological Society of London conferred upon him in 1875 the Wollaston medal, one of the highest honours in their power to bestow. In 1872 he was unanimously elected an honorary member of this Society, and ever evinced a great interest in its welfare.

I cannot conclude these few remarks in memoriam of Professor de Koninck in more appropriate language than by quoting the words of Professor Judd in his presidential address to the Geological Society in 1888:—"Deeply beloved by a large circle of pupils and friends, honoured by many marks of favour, not only from his own sovereign, but from those of other states, and acknowledged all the world over as the greatest authority in all questions pertaining to his own particular studies, our distinguished foreign member died on the 16th July, 1887."

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No. XXXII.—Note on a Section of Boulder-clay, containing a Bed of Peat. By Robert Dunlop.

[Read 31st May, 1888.]

About two miles east of the town of Airdrie, at Burnhead quarry, there has lately been exposed a section of clay, apparently Boulder-clay. I do not positively assert that it is so until I have made further investigations, and, therefore, I only wish now to make a statement of actual facts which can speak for themselves. Indeed I would not have brought the subject before your notice at all at this time unless I had thought that during the summer months there would be a good opportunity for some of the members to examine the section for themselves, and perhaps decide the question, especially as every one knows that when a section such as this is fresh, it is much better seen than after weathering influences have had an effect on it. I may, however, add that several geologists of note who have visited the quarry have expressed their opinion that the section is true Boulder-clay.

This section of Boulder-clay, containing a bed of peat which was brought to light through a downthrow of the dolerite on the north side of the quarry, is about 12 feet thick, and the Boulder-clay appears to lie both above and below the peat, but as it dips to the north, the thickness cannot be at present ascertained. The peat is 17 inches thick in the section; when split up into layers, as it readily does, it is of a pale-brown colour, but turns of a darker shade when exposed for a few minutes to the light. Embedded in it are boulders of various sizes, consisting of sandstone, gneiss, etc., but these seem to be irregularly scattered through it, and do not form any defined layer. One which I now exhibit was found almost in the centre of the peat bed by Mr. Wm. Connochie, and it can at once be seen to be water-worn, with faint traces of ice-markings. The sandstone boulders, some of which are large, are almost all in a very soft condition, but if carefully handled they can be seen to bear traces of being water-worn.

Mr. James Bennie of the Geological Survey of Scotland, and a member of our Society, who took two large bags full of the peat to wash, says that its chief characteristic is the extraordinary

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number of seeds of plants it contains in thousands upon thousands, but mostly belonging to very few species. The seeds of the common Mare's-tail, *Hippuris vulgaris*, are found in layers, also those of the Bogbean, *Menyanthes trifoliata*. There is a complete absence of the remains of trees generally common in our peat beds, except leaves, which after examination may probably turn out to be those of the Willow.

Some layers in the peat are made up almost entirely of Mosses, plant life of every other kind being seemingly absent, and in the lower layers remains of Beetles are very plentiful. In some parts of the section the peat is found to be greatly contorted, more especially in front of a large boulder which is seen partly embedded in it. The force which seems to have caused this contortion or crumpling appears to have been directed from the west, and therefore corresponds with the direction of the ice-markings on the top of the dolerite (*i.e.*, from west to east). It would appear that this peat was laid down in water, and a remarkable feature in it is the absence of sand. Chemical analysis, after the sample was air-dried, gives the following:—Volatile matter, including water, 70 per cent.; ash, 6 per cent., of a bright red colour, being almost a pure oxide of iron. The particles of iron have been so well absorbed by the plants that if carefully burned their structure can still be seen.

Above the peat, a bed 11 inches thick is almost entirely made up of sand, with partings of a fine clay through it. Above this is the upper portion of the Boulder-clay. It is 4 feet thick, and has all the appearance of the upper layers of the Boulder-clay about Airdrie. On washing about 14 lbs. of it, I got a residue of 10 per cent. which would not pass through a fine sieve of 200 holes to the inch. This consisted of small pieces of sandstone, ironstone, quartz, gneiss, and other rocks, mostly all water-worn, and the larger and harder ones showing ice-markings. Above this Boulder-clay there is a bed of 2 feet of peat, with trees standing up through it, and which would appear to correspond with the modern peats around Airdrie. Above the peat is at present 3 feet of alluvium, but I have some doubt as to whether it does not consist of soil which was taken from the top of the quarry in its earlier stages. The larger angular stones are at the bottom, and the finer material on the top. Another noticeable feature in this section is the occurrence, about 18 inches above the lower peat and in the Boulder-clay, of a

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layer about 4 inches thick of small specks of amorphous Vivianite, some varying in size from $\frac{1}{8}$ of an inch to 1 inch. The chemical composition of this mineral is $3FeOP_2O_5 + Fe_2O_3P_2O_5 + 15$ aq. It is a phosphate of iron, and is frequently described under the name of Blue iron earth. Within the last few years it has been found in its crystalline form in the cavities of bones of various animals discovered in some of the Ayrshire crannogs. Its occurrence here seems to denote that animal remains have been at one time present, though whether they belonged to some of the larger mammalia there is, as yet, no possible means of discovering.

Note by the Rev. Canon Fowler, Lincoln, on the Insect remains obtained from washings of the Peat in Burnhead Quarry, Airdrie, by James Bennie, Geological Survey of Scotland.

The beetles observed belonged to two groups, the Carabidæ or predaceous ground beetles, and the Rhynchophora or weevils, and were restricted to two or three genera.

CARABIDÆ—

Pterostichus, near *strenuus*—head, thorax, and elytra of several species.

Anchomenus—an elytron apparently belonging to a member of the genus.

Besides the above, there was an elytron of a large species apparently belonging to the Carabidæ, probably one of the larger *Pterostichi*.

RHYNCHOPHORA—

Otiorhynchus maurus—head and thorax of several specimens, and one perfect elytron. This species as far as Britain is concerned is almost if not quite confined to Scotland.

There were also a few fragments of elytra of a bright violaceous metallic tint which I could not identify with any species known to me.

List by Clement Reid, F.G.S., Geological Survey of England, of Seeds from Peat-bed in Burnhead Quarry, Airdrie, from washings by James Bennie, Geological Survey of Scotland.

Ranunculus aquatilis, Linn.
Prunus padus, Linn.
Potentilla Comarum, Linn.
Hippuris vulgaris, Linn. (ripe and unripe, some bitten).*

* In the interglacial peats from the Edinburgh district I found many seeds, especially those of the Bogbean, which had been gnawed, by mice I believe.—J. Bennie.

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Apium nodiflorum, Reich.
Carduus, sp.
Menyanthes trifoliata, Linn.
Betula nana, Linn. (leaves only).
Empetrum nigrum, Linn. (berries and seeds).
Potamogeton, sp. (also embryos).
Carex dioica, Linn.
„ *rostrata*, Stokes.
Isöetes lacustris, Linn.

No. XXXIII.—Ancient Coal Workings in the Ell Coal, Glenclelland, Wishaw. By John R. S. Hunter, D.Sc., LL.D., F.R.Ph.S.E., *Honorary Member.*

[Read 14th April, 1887.]

[Abstract.]

After showing how the first use of coal amongst our prehistoric ancestors may have been brought about, the author touched upon its occurrence in a calcined form in the old crannogs and other early habitations, proceeding to describe as follows the discovery of unrecorded coal workings in the Wishaw district.

A curious discovery of old coal workings recently took place in Glenclelland Pit, Wishaw, where, when working the famous ell coal seam, the miners unexpectedly came into some old and disused workings. The method adopted for taking out the coal seemed to have been done in a remarkable fashion, but at the same time one of the safest which could have been chosen by an experienced manager of to-day. The entrance to these old drifts appears to have been on the banks of the beautiful Calder Water, on the Wishaw side, above Coltness Mill, although no outward evidence of any disturbance here exists, the sides of the glen being covered with large trees. To a probable point here for the opening to where the old workings were lately found would be at least 150 yards. The depth of the coal seam here would be about 5½ feet, the roof coal being arched, and the width of the working places from 7 to 8 feet. The old miners had apparently a good idea of the quality of coal, as in these workings only the best seam was taken out. Wheelbarrows of some description were used to convey out the coal, as marks of wheel runs were visible. Prints of human feet were also observed on the soft clay or pave-

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ment, the markings indicating that some soft material had been worn to protect the feet from sharp fragments. Apparently only the larger pieces of coal were taken, as small heaps of dross were to be seen on either side of the runs.

A curious wooden bowl or platter was found in the course of the exploration, but after being carried out to the carpenter's shop by the foreman for further examination, it crumbled into pieces. It was from 8 to 9 inches across, and about 3 inches in depth, and was thought to be made from the wood of the Whitethorn.

There are no existing records of any old coal workings in this neighbourhood, and, therefore, it is impossible to speak authoritatively as to their date, or as to the workers, but the fine workmanship displayed in the winning of the coal shows that they thoroughly understood the best and safest methods of working.

Dr. Hunter went on to state that from the form of the roof arch, and the excellence of the arrangements, he was inclined to believe that the workings in question had been made by the Romans or under their superintendence. Their military roads were still existent in the district, and as from the remains found in various places occupied by them it was evident they understood and applied the use of coal, it was no great stretch of imagination to suppose that they had mined on Calder Water.

No. XXXIV.—Glaciation and Raised Beaches in Jura and Islay. By James Anderson.

[Read 13th January, 1887.]

When passing down the Firth of Clyde a geologist never fails to admire the polished rock surfaces about Kirn. I had frequently wondered, however, why the rocks along its shores further south, as at Toward Point, Tighnabruaich, Ardlamont, and thereabouts, did not show the same freshness. Although when viewed from a short distance they everywhere exhibit undoubted ice-moulded outlines, they also show, when closely examined, very old and weathered surfaces. The same appearances are also presented on approaching the shores of Islay and Jura; where the numerous outlying small islets of trap rock show an excessively wave-worn, rutted condition. When they are seen from the deck of the

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steamer this ancient appearance is strikingly remarkable, and at no point can any freshly glaciated rock-faces be seen.

When I first saw them I had a preconceived notion that these islands had been glaciated by ice moving down the Firth of Lorne, but a sail along their eastern shores dispels that idea. I expected to find a dressed outline when they were viewed from the north, and a rugged one when seen in the opposite direction, but the reality was that the former showed by far the rougher outline of the two. The shape and contour of the string of islands comprising Islay, Jura, Scarba, Luing and Seil, narrowing and shrinking in size till they vanish altogether, suggest the idea that the northernmost of them had sustained the heaviest assault of the marching ice, and had consequently suffered most, but the composition and structure of Jura altogether militates against such an idea. The whole western side of that island is composed of very friable quartzite sandstone, cropping out from the shore to the mountain-tops, and dipping inland at a very high angle. This sugar-like quartzite is so very loose in its composition as to be unfit for even the trifling buildings required in the island, and stone has to be imported for the purpose. On the eastern coast the island is guarded by immense buttresses of trap, till we get on to schists dipping into the sea, and extending from the Sound of Islay to Lowlandman's Bay. Between the schists, and the quartzites which form the main bulk of the island, a series of beds of a black mineral exactly like blind coal intervenes. It resists the hammer, and where it is built into dikes the action of the weather seems to have no apparent effect upon it. From beneath it rises the quartzite formation, of which the upper beds are very different from the lower. If these upper beds were denuded of all that now overlies them they would, I think, form one unbroken sheet of flinty glassy material, extending from the shore to the peaks of the Paps of Jura, which, but for them, never would have existed.

Such being the formation of the island, it seems to follow that a glacier travelling from the north down the Sound would attack the strata "end on," as we might say, though at some points, no doubt, projecting trap-covered headlands would have deflected the ice-flow into the heart of the island. It is difficult to conceive how moving ice, working directly into the seams and weakest sections of such strata as still remain, could have spared any of them at all. In fact, the great body of sugary quartzite could

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hardly have remained unless it had been directly protected from the action of such a destructive agent as moving ice. The contour of the island and the surfaces of the harder rocks show sufficient proofs that they have been moulded by a great body of ice moving from the mainland towards the ocean, but all indications I could observe pointed to a movement from east to west, directly from Cantyre across the Sound of Jura. Such a stream would first encounter the great walls of trap which we see rising on the shore of Jura and in the small isles. It would then pass over the schists and the hard indestructible, flinty quartzites. I rather think there would not be much movement in the lower portions of a sheet of ice that would fill all these immense depressions, and at the same time cover the mountains of the mainland. But move it did, and its action is well seen at an elevation of about 1200 feet, on the neck or shoulder between Ben Glass and Ben-a-Chalois, which forms the watershed at the head of Asdale Water. The rocks here are the flinty quartzites, which continue upwards on each side to form the peaks named, but are here broken down. On crossing the watershed into Glen Asdale the level drops instantly about 400 feet, leaving a deep trench which shows where the ice had ploughed into the softer rocks beneath, and formed a corrie about one mile long, which extends from the watershed to Loch Asdale. There is hardly any fall, the little stream which gathers in it being mostly a series of half-stagnant pools. I think there cannot be any doubt that this curious depression has been formed in the way I have indicated, a trap dike which passes through it, and is planed down to the level of the soft sandstone surrounding it, being only noticeable by its green surface, and by its forming a waterfall where it crosses the stream. But this glen contains a curious enigma. A bank of loose incoherent rubbish—earth and angular stones of local origin—occupies its centre from end to end. This bank is about 50 feet high and 200 to 250 feet broad at its base. It is obvious such material could not have been left by a glacier of just sufficient power to come over the watershed from the east, but it seems rather to have been the work of a much more recent ice period, when the frozen snows from the surrounding hills were sufficient to scrape down the loose material from both shores and deposit it in the centre, but were lacking the power to clear it away.

The mountain range which culminates in the Paps of Jura seems

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to have been of sufficient elevation to produce a local glacier, but the form of the mountains has carried it off mostly towards the north and west. On the north side of the range an enclosed valley lying in the centre of the island between Cnoc an Ime and Cnoc Mor nan Cnoc, and about three miles in diameter, seems to have been filled with ice and to have overflowed chiefly over its western border into West Loch Tarbert, but it has also escaped eastward through a narrow streamless glen debouching at Gatehouse, where it has polished the back of a large body of trap till it looks like an upturned copper pan, and in striking contrast to the decayed, ancient, weathered, and wormeaten-like appearance presented by the ice-moulded rocks both north and south of it.

The bottom and sides of the central valley show intensely polished surfaces everywhere. The valley is enclosed on the west side by two or three bosses of rock, and over and between these the glaciation has been especially severe. Where it has plunged down into Loch Tarbert the ice has grooved channels like artificial docks and canals through the rock, and this is best shown opposite the northmost outlet. A little to the eastward of this I observed on a precipitous face two deeply cut recesses in the rock-face, evidently formed by considerable streams, where no streams could possibly run now. I think they may have been waterfalls on the course of streams which drained the northern side of the ice-field, outlets of the water which may have accumulated on that side. Returning again to the eastern side of the watershed we see that the ice flowing eastward from the main range has brushed down all weatherworn rubbish, and has imparted a fresh and smooth appearance as far as it has extended. The heaviest stream of ice on this side has followed the course of the Corran burn, and has brought down a large quantity of detritus which fills the lower course of the valley. The stream has cut deeply into this rubbish, and the banks show no appearances of stratification in its upper reaches, but from the road down towards the sea increasing evidence of dressing and levelling is thus shown, as if the sea had stood high enough to spread the debris out as it was laid down. This moraine matter is full of angular stones and covers a considerable extent of ground; and I think that the sea must have stood at the 40 feet level when this glacier ceased to carry down material. About a quarter of a mile south of Corran Bridge, and separated from the road by a small field, is a curious vestige of its work.

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It is a section of a rubbish heap evidently occupying the southern limit of the moraine accumulated by the glacier in the valley, and lying close to the foot of the hill. It looks exactly as if a contractor had been removing a little mountain of rubbish and had failed to complete his contract when about four-fifths were done. The sea has apparently had time to level all before it retired, except this little corner, and yet the material is so loose and free that I cannot conceive why it has been left, unless it has been protected by an ice-foot or stranded field-ice. A similar accumulation of debris is found further south in the course of the Chapel burn, but of greater depth. Between these two points the hillside is pretty well brushed down, and little foreign material is found, showing that the ice from the Paps had been moving down along the whole hillside between these two points; but both north and south of these places old and worn boulders from the mainland are abundant, and while the material through which Corran burn and Chapel burn cut their way is loose and brownish in colour, the Kiels burn, a little to the south of Chapel burn, cuts through a light-coloured Till of a totally different character, being much firmer, and not unlike fire-clay in appearance, and full of travelled and worn boulders largely composed of granite, while very few belong to Jura. All the material to be seen in the course of the Chapel burn belongs to the native rocks, but the Till and the most of its contents seen on the lower course of the Kiels burn seem to me to have been carried across the sound of Jura from the mainland.

After seeing the fresh foot-prints of the local glacier in Jura the mind instantly reverts to what is seen in the Firth of Clyde, and it needs no further argument to prove that the latest glacier which formed in Loch Long and travelled down the firth had never reached Toward Point. If any guess could be ventured as to the relation in point of time between the two periods, based upon the relative freshness of the glaciation, I would say that the interval separating the dates of the latest local glacier and the older glacier must have been immeasurably greater than the period which divides the local glacier from our own time.

During my visit I gave particular attention to the Raised Beaches of these islands. Such occurrences are undoubted facts, but there were some points connected with them which I wished to investigate. While the lowest Raised Beach is so natural and so clearly marked that the sea might return to-day and re-occupy the

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tract, it is very different with the higher or 40 feet beach, of which the existence cannot be doubted, for the rolled gravel is there as the sea left it, though the hollowed and cave-worn rocks are rarely to be met with. Raised Beaches can be traced all round the islands, but I have not seen them so well developed as round the head of Loch-in-dal in Islay. The road from Bridgend to Port Charlotte is formed along them for about two miles west of the former place, and both the 25 feet and the 40 feet beaches cover perhaps a square mile each. The gravel of the higher level is more rounded and of rather smaller size. The lower level is so free from sand or soil that the rounded pebbles are still uncovered by herbage. They are bounded on the western side by a cliff composed of loose earth and angular stones. At the base of this cliff, and between it and the outer and higher terrace, there is a broad trench 5 to 8 feet lower than the level of the old beach. Like the moraine heap at Corran this cliff, nearly perpendicular, about 100 feet high, and composed of material easily washed away, could hardly have remained as it is unless it had carried an ice-foot. The trench at its base may have been its seat. I followed the landward margin of these beaches for some distance and found them sharply defined by the rising ground. At no higher level than 40 feet could I find any rolled stones—all being angular. Although the limits of the 25 feet level are generally marked by sea-worn rocks, I have scarcely found an instance where the 40 feet level is so marked. In these Raised Beaches in Islay the configuration of the land all round would readily lend itself to the action of the sea, but at no point on the landward side does the 40 feet level show any margin of sea-worn rock. As in other places, it is here bounded by a depression, which leads me to think that our coast has been clad by a continuous ice-foot when the sea stood at the 40 feet level. I now think that the limits of the contemporaneous glacier on the mainland may be traced with some exactness. The rough weathered appearance of the schists about Tarbert and the lower parts of Loch Fyne lead to the supposition that the glacier in Loch Fyne had not passed Ardrishaig. The hillsides about Tighnabruaich do not look as if they had been recently polished, and the great Clyde glacier, which has left its foot-prints on the shores, especially about Kirn and Dunoon, may not have reached the Cumbraes or even Toward Point.

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No. XXXV.—Polar Ice-caps and their Influence in changing Sea Levels. By Sir William Thomson, LL.D., F.R.S., etc., Professor of Natural Philosophy in the University of Glasgow.

[Read 16th February, 1888.]

The subject I have to speak about this evening is not exactly geological. I may say that the immediate proposal to lecture on such a subject is to be found in an extract which I shall read to you from Dr. Croll's book on *Climate and Time*. In chaps. xxiii., xxiv., of this volume Mr. Croll deals with the physical causes of the submergence and emergence of land during the glacial epoch, and he has given some very curious, while at the same time mathematically correct, explanations of the effects due to a certain assumed displacement of ice from one hemisphere to the other. After loyally calling attention, in his opening words, to the fact of his having been anticipated by M. Adhémar, (in a work *Révolutions de la Mer*,) in the suggestion of heaped-up ice being a probable cause of the submergence and emergence of land, Mr. Croll proceeds to investigate in a very masterly manner the probable effect of an ice-cap of a given description. In this connection Mr. Croll refers to an article on the subject published by him in the *Reader* for January 13, 1866, and the extract which I will now read to you from this volume, *Climate and Time* (pp. 372-374), consists of a note written by myself, at Mr. Croll's request, in regard to the objection brought forward in that article :—

"Mr. Croll's estimate of the influence of a cap of ice on the sea level is very remarkable in its relation to Laplace's celebrated analysis, as being founded on that law of thickness which leads to expressions involving only the first term of the series of 'Laplace's functions,' or 'spherical harmonics.' The equation of the level surface, as altered by any given transference of solid matter, is expressed by equating the altered potential function to a constant. This function, when expanded in the series of spherical harmonics, has for its first term the potential due to the whole mass supposed collected at its altered centre of gravity. Hence a spherical surface round the altered centre of gravity is the *first* approximation in

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Laplace's method of solution for the altered level surface. Mr. Croll has with admirable tact chosen, of all the arbitrary suppositions that may be made foundations for rough estimates of the change of sea level due to variations in the polar ice-caps, *the* one which reduces to zero all terms after the first in the harmonic series, and renders that first approximation (which expresses the *essence* of the result) undisturbed by terms irrelevant to the great physical question.

"Mr. Croll, in the preceding paper, has alluded with remarkable clearness to the effect of the change in the distribution of the water in increasing, by its own attraction, the deviation of the level surface above that which is due to the *given* change in the distribution of solid matter. The remark he makes, that it is round the centre of gravity of the altered solid and altered liquid that the altering liquid surface adjusts itself, expresses the essence of Laplace's celebrated demonstration of the stability of the ocean, and suggests the proper elementary solution of the problem to find the true alteration of sea level produced by a given alteration of the solid. As an assumption leading to a simple calculation, let us suppose the solid earth to rise out of the water in a vast number of small flat-topped islands, each bounded by a perpendicular cliff, and let the proportion of water area to the whole be equal in all quarters. Let all of these islands in one hemisphere be covered with ice, of thickness according to the law assumed by Mr. Croll—that is varying in simple proportion to the sine of the latitude. Let this ice be removed from the first hemisphere and similarly distributed over the islands of the second. By working out according to Mr. Croll's directions, it is easily found that the change of sea level which this will produce will consist in a sinking in the first hemisphere and rising in the second, through heights varying according to the same law (that is, simple proportionality to sines of latitudes), and amounting at each pole to

$$\frac{(1-\omega)it}{1-\omega w},$$

when t denotes the thickness of the ice-cap at the pole, i the ratio of the density of ice, and w that of sea-water to the earth's mean density; and ω the ratio of the area of ocean to the whole surface.

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"Thus, for instance, if we suppose $\omega = \frac{2}{3}$, and t = 6,000 feet, and take $\frac{1}{6}$ and $\frac{1}{5\frac{1}{2}}$ as the densities of ice and water respectively, we find for the rise of sea level at one pole, and depression at the other,

$$\frac{\frac{1}{3} \times \frac{1}{6} \times 6000}{1 - \frac{2}{3} \times \frac{1}{5\frac{1}{2}}},$$

or approximately 380 feet.

"I shall now proceed to consider roughly what is the probable extent of submergence which, during the glacial epoch, may have resulted from the displacement of the earth's centre of gravity by means of the transference of the polar ice from one hemisphere to the other."

I wish you to notice particularly the last sentence of that note, for it is to that my attention has been called. I was quite unaware that by this statement I had placed myself under any obligation, but it so turns out. A friend suggests that the quotation marks as applied to that sentence, be here deleted, and the passage given as Mr. Croll's own. Mr. Croll may well have said the same, for after quoting my note he at once proceeds to carry out that intention. For myself I can only say that I have tried to fulfil my obligation, and I feel I can throw but little additional light on the subject. Nor do I need to do so, as it is quite unnecessary for me to carry out the intention, since Mr. Croll has done it with all the means that occurred to him as bearing on former estimates, in regard to this very important and difficult subject.

With regard to the effect on sea level Mr. Croll's principle, as set forth in pp. 368-369 of his book, is thoroughly correct, and shows the remarkable power he possessed of grasping the subject, and dealing with it by a simple geometric construction which led to the same result as Laplace's mathematical analysis. For the stability of the ocean it is necessary that the specific gravity of water be less than the specific gravity of the solid, and it is less as we know. The mean density of the earth is about $5\frac{1}{2}$—or more exactly 5·6—times the specific gravity of water. This statement favours Laplace's theory as to the requisite for stability, but it is curious that Laplace did not notice the simple view that if the solid part of the earth had a specific gravity less than that of water it would tend to float and leave the water on either side of

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it. For example take a globe of liquid of any size (Fig. 1) and let us suppose a small spherical portion at A to become solid. The configuration of solid and liquid would remain stable provided the solidified portion remained of the same density as the liquid. If the solidified portion acquired a density greater or less than that of the liquid, the configuration as shown in the figure would become unstable, and the small sphere A would take the position A′ or A″, in either of which two cases the configuration would be again stable.

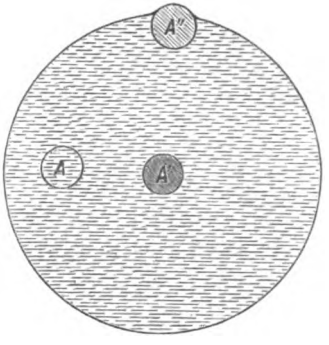

Fig. 1.

Look now at Fig. 2 and suppose the outer circle to represent the section of a globe 8,000 miles in diameter, and let the inner circle represent the section of an enclosed globe 2 miles less (7,998) in diameter. Suppose the outer envelope to be water, and the inner globe to be solid matter, of density equal to or greater than that of water, then the configuration of Fig. 2

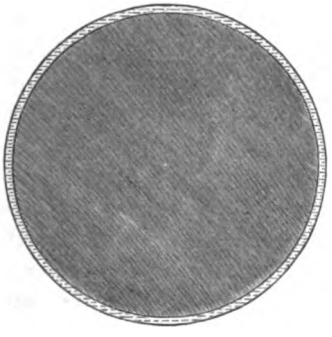
Fig. 2.

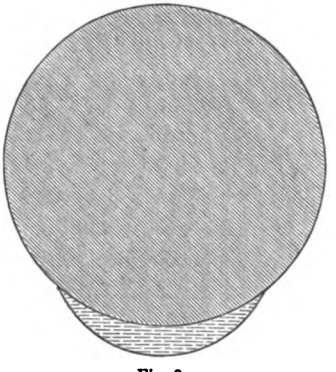
Fig. 3.

would evidently be stable. On the other hand if we suppose the inner globe to be solid but of density less than that of water, say equal to that of cork or wood, then the water would no longer form an envelope enclosing the solid, but would run together and the configuration of solid and liquid would be represented by a section such as Fig. 3.

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Mr. Croll goes on to inquire what would be the probable effect, upon the level of the ocean, of changing the centre of gravity of the earth, if we suppose a quantity of ice (a polar ice-cap) to be transferred to one pole from the other. I shall just say one word as to the attraction of the polar ice-cap.

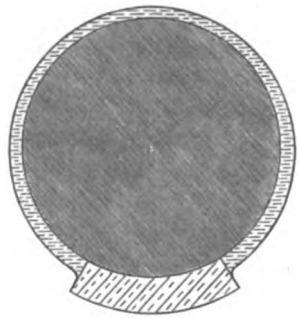

Fig. 4.

We have here (Fig. 4) a globe. Suppose that somehow or other a portion of ice was on the Antarctic continent, what would be the result? It would be that the polar ice-cap would attract the water, so that the water which was maintained at a certain height before that transference was made, would be drawn up to a higher level (as shown exaggerated by the outline in the Fig.) by the attraction of this mass of ice. The calculation for the result is merely a piece of mathematical book-keeping with which I need not trouble you.

There is just one other point which belongs to further explanation of Laplace's theory. That first theory of stability is really so clear that it is a wonder Laplace did not see it straightaway. But he was so intensely mathematical that he often did not see the simplicity of the results which he attained by complicated mathematical analysis. Suppose you shift a quantity of ice from one place to another on the globe; and suppose, instead of sea-water of its actual density, we had ideal water a twentieth part of the density of sea-water, then the attraction of this solid mass of ice upon the water would be calculated simply by the attraction of the ice upon the ideal water. The figure would be such that the surface of the ideal water would be everywhere perpendicular to the surface of the globe. But when we deal with real sea-water we have a piece of very delicate and nice mathematical book-keeping which reminds one of certain rules in Compound Interest. The ice attracts the fluid it displaces; but the fluid displaced itself attracts the remaining fluid and so contributes to the resultant attractive force. First calculate the amount of the attraction on the water due to the ice-cap alone; then calculate the increase of the attractive force due to the displaced water; then calculate this increase, to the second degree of approximation, and so on; and

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thus you get at the result, just as in the very simple case put by Croll. Of course there have been different calculations. Mr. H. D. Heath and the Rev. O. Fisher made calculations which differed somewhat wildly from mine as well as from Croll's, but I believe them all to be consistent. My result, 380 feet, seemed to be immensely smaller than the others. In point of fact, Croll omitted to notice that mine referred to an ice-cap gathering on an ideal set of islands, and that I supposed the whole land to be distributed uniformly, and the ice to be placed upon the top of these islands. I took the actual proportion of the area of land to water, roughly estimated, as being one-third land and two-thirds water; that was in 1876. To bring my result into comparison with the others quoted, you must therefore treble it, because I took only one-third area as covered with ice. Three times $380 = 1140$, which is my number on a certain supposition; while Heath's is 650 on a supposition not quite the same as mine. Pratt's estimate is still greater—something like 2,000 feet.

Now, if I could say anything to throw light upon the real question of extensions of ice in the southern or northern polar regions, and the effect of such extensions upon the sea level and upon the climate in past times, I should feel my attempt was certainly not insignificant. But I cannot even look upon such an attempt; I can merely point out certain fallacies and set certain limits to former suppositions. We cannot have an ice-cap on the Antarctic continent $12\frac{1}{2}$ miles thick, as Mr. Croll has calculated. I think I can bring evidence against this. But Mr. Croll's argument does not at all stand upon that number; he is satisfied with a small fraction of it, 3,000 or 5,000, or 12,000 feet, instead of 65,000 feet. He is satisfied with an ice-cap of a comparatively moderate thickness as a sufficient cause for some most important fluctuations of sea level which geological history proves to have taken place. It seems to me that Croll is here meeting my case, and we may find the most probable explanation of some of our familiar changes of sea level—familiar even to people who are not geologists—in Croll's supposition of shiftings of ice either on the Antarctic or the Arctic hemisphere.

In the first place I shall ask you to imagine that the Antarctic continent for some unknown cause had at one time a distribution of ice over it thicker by 1,000 feet than at another time. To be more accurate I would say 1,200 so as to correspond with the area

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equivalent to 1,000 feet of water. Mr. Murray has made a very careful estimate of the area of the Antarctic continent, which shows that the area is about one-fortieth of the area of the whole earth. Croll makes it more; but Mr. Murray has given us the more recent and more probable estimate. Now I shall merely ask you to think of a great ice-cap melted off the Antarctic continent, an ice-cap 1,200 feet thick equivalent to 1,000 feet depth of water. Imagine this mass of ice melting and flowing into the ocean; it would just raise the level of the ocean by one-fortieth of a thousand feet, a quarter of a hundred, or 25 feet. Our latest change of sea level here on the Firth of Clyde was only 10 feet. We do not know exactly the date, but it is quite certain that it was not within very many thousand years. The water-level in the Firth of Clyde was then 10 feet higher than it is now, and that change of level will, on the theory I have stated, involve the melting of only about 400 feet of ice from the southern continent, which could, of course, raise the water 10 feet all over the world. When the theory of gravitation is taken into account in the manner I have indicated, the water thus brought to one of the poles and converted into an ice-cap, or the water that flows away from the melting ice-cap leaving a deficiency of solid water, does by its own gravitation always exaggerate the effect. Before we go into any consideration whatever regarding the possibilities of thickness of Antarctic ice, I think we may say that if it is 500 or 600 or 2,000 feet thick at one time, it may be at another time more or less, and if so we should have corresponding changes of level all over the world. We have had such perfectly feasible cases put before us by Taylor, Heath, and others as to the thickness of ice at either Pole, and in respect to the level of the sea.

Before taking up the question of how thick the ice may be at either Pole, think a little of the shape of the earth and ocean around the North Pole. There is the North Pole (see Fig. 5, giving an outline chart). Here is Greenland and Iceland. You enter into the Arctic Ocean west of Iceland; then you come on to Spitzbergen, and further north to Nova Zembla, or again away to the east. This (the Arctic) ocean is merely a landlocked sea. The Behring Strait is only fifty miles wide and fifty fathoms deep, so that you may look upon the Arctic Ocean as practically stopped here. America is an island separated from the north-east of Asia by Behring Straits; and Europe, Asia, and Africa constitute

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another island, though Africa may be considered a separate island because of the Suez Canal. The Arctic Ocean connects with the

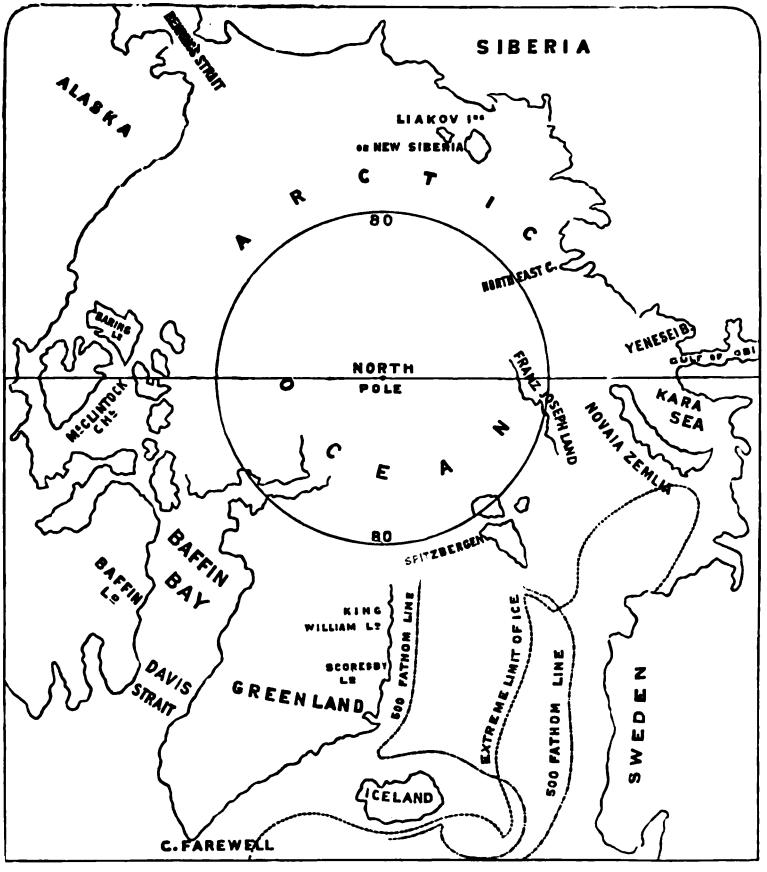

Fig. 5.

North Atlantic chiefly by the aperture between Norway and Greenland, with the large island of Iceland—one third of the way across from Greenland, and two thirds from Scotland. If a barrier were to be formed, as by raising slightly the bed of the ocean between the north of Scotland, Faroe Island, Iceland, and Greenland, the Arctic Ocean would become a lake. Such a barrier indeed already exists in a partial degree; we see from this chart that there is a zone of comparatively shallow water all the way

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across from Norway to the Faroe Isles, Iceland and Greenland (see 500-fathom depth lines in Fig. 5). There is another opening by Smith Sound, and Captain Markham's expedition went up that narrow neck; but if it were closed the Arctic Ocean would practically become an inland lake.

Now what about the ice here? In the first place, so far as we know, the North Pole is under water. We know of no land north of Franz Josef Land. The farthest north that has yet been reached was by Captain Markham, who went 28 miles from the shore, and reached the latitude of 83° 20′ 26″ N. On boring the ice it was discovered to be only 64 inches thick, and they found water—76 fathoms—beneath. It was water 28 miles from the shore. They went over floating ice, and only succeeded in getting over something like 30 miles; for floating ice is exceedingly rough and hummocky in character, making the passage difficult for travellers. All we know then about the North Pole is that it is probably floating ice. There is also very strong, if not absolute, evidence to show that there is great freedom for currents to flow under the ice across the polar region. Here is a piece of wood (specimen exhibited) from the banks of a Siberian river carried down in a floe of ice. That ice floe with the wood was found in latitude 76° 30′ N., and longitude 40° W. The pine tree structure of the wood implies that it grew in a country far north. It came, as I said, embedded in an iceberg, and there is no possibility of that except by its being carried, by one of the great Siberian rivers which flow into the Arctic Ocean from the land of Siberia, across the North Pole into the latitude where it was found. There may be islands round the North Pole, but we know nothing of such. The Arctic Ocean, so far as known, has no very great island in the middle of it. This (second specimen shown) is a piece of another tree which was found fixed in an iceberg that floated across the North Pole, and there is the mud which was found on it. The wood is evidently a piece of a fir tree, with branches chiefly on the one side.

I want now to consider the physical properties of ice, so as to learn what limits, if any, these may give to a possible thickness of floating ice or of an ice-cap. Can ice stand in the form of any iceberg 1,500 feet thick? Comparatively speaking, icebergs have been said to stand at a height of 600 or 800 feet: at least that was the assumed measurement. The highest iceberg recorded is

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700 feet, but there is a doubt whether it was even so high as that. What then would be the physical condition of a mass of ice at the North Pole? Think of the ice with snow falling on it at the rate of 3 feet annually. (I always reckon in feet of water, so that if I speak of 3 feet of snowfall, I mean sufficient to form 3 feet of water when melted).

In considering this question I must first call your attention to Forbes's celebrated theory of the viscosity of ice, and his viscous theory of glaciers. Forbes has demonstrated it by experiment; having studied the glaciers moving down the Swiss valleys and compared their motion with that of pitch. And now I am going to show you that motion in shoemaker's wax. Here is a piece (first model) you see what it has been doing since last Monday when it was placed a roughly rounded lump on the board: it is now flattened out like a pancake. Then here is another piece of shoemaker's wax that was placed, on the 2nd December, 1886, at the bottom of this jar with 10 bullets on the top and 14 corks placed below. If you look at the bottom of the jar you will see signs of bullets at the bottom, and you all see that the corks are making way through the wax and will be floating on the surface by and by. I may inspect the corks a little by carving into one of them. Probably in a fortnight that one will have taken advantage of this aperture I have just made. Thus, you see, in little more than a year the bullets have all disappeared beneath the wax, and the corks are coming to the surface.

But there is another experiment going on in this same jar. Three small cylinders of wood were each weighted by a piece of lead attached to one end, so that each mass—wood and lead—just floated on water. On the 4th February, 1887, these three cylinders were placed on the surface of the shoemaker's wax, one with the weighted end down, another with the weighted end up, and the third on its side; and there you see what has been going on during the year. The first cylinder has sunk steadily into the wax; the second has toppled over and is sinking to a vertical position with the weighted end down; the third has attained a vertical position and is nearly as deep in the wax as the first.

I would call your attention to another illustration of the viscosity of this seeming solid. There is a piece of shoemaker's wax which was levelled down with heat and then allowed to become cold. Two months ago, on the 16th December, 1887, we

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placed *on* its surface the 16 pieces of wood--cylinders and cones—which you see are very slowly sinking into the wax. Here again I have pieces of wood shaped, and some of them with lead attached, exactly as are those on the wax. See the positions they take, and how quickly they do it, when I throw them on this fluid substance—water. Look at this cone in water. That cone (in wax), now so much inclined, was upright on 16th December, and I shall not say where it will be in the course of a short time. There is a long cylinder in water—you observe it falls down on its side. Then here is a shorter cylinder in water—it falls into an inclined position. Here again we have a very short cylinder which would be clearly unstable with its edge down. Then we have a cylinder with lead on it—it is stable. It is a counter-part of that which floats in water with the lead up, and would also float with the lead down, but it was placed in its present position. Now, there you have floating bodies which in a second of time, in water, do that which those similar bodies *floating* in wax are to be gradually doing in the course of the next few years. So that it is only a question of time between water and the shoemaker's wax.

Look at that globe of shoemaker's wax floating in water. Just watch it; if you could watch it for a long enough time you would see what would happen. But to economize your time look at this second one, which was placed in water last Tuesday exactly as you see the first—a globe. It is now like a pancake. It has flattened itself on the surface of the water to a round cake, of which the section is shown approximately by Fig. 6.* Our water

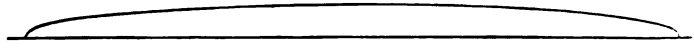

Fig. 6.

was slightly hot, as it would take two or three years to get as flat as that in cold water. We have hurried it up this evening by hotter water, but I am now going to leave it to itself.

Then here is a model—a wooden board having its edge shaped to represent the various forms of shore line, and covered with a layer of wax—illustrating the Arctic ice on the viscous theory. This was prepared last Monday, and has been somewhat hurried

* The curve is accurate for an *ice*-cap, and was drawn from the equation $y=b\left(1-\frac{x^3}{a^2}\right)^{\frac{1}{3}}$ with b (height)=2 inches, and a (diameter)=20 inches.

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up by heat. You see the wax spreading itself on the plane, and tumbling over the edges. Here is another model, which was only started to-day, placed in water so that the board is just at the water level. You see we have the continental features complete with a long slope down to the sea on one side, a deep gorge, a precipice, and yet another slope down into the sea; and these variations of boundary are sufficient to show the various effects due to the shape of the land under a plastic body: everywhere ice flowing seawards breaking off when sea borne, and making ice-bergs.

That shoemaker's wax is a substance which we know and see to be plastic; here is a substance—ice—which we might not know to be plastic, but which Forbes proved to move as a plastic body in the Swiss glaciers. My brother's theory of the plasticity of ice, in virtue of melting by pressure and regelation, is admirably illustrated by an experiment of Mr. J. T. Bottomley. Here is a piece of clear ice having a piece of copper wire hung upon it, with a weight attached of 56 lbs. This wire will not go through the ice in less than an hour, but we see it already sinking into the ice—at the corners it is about half an inch in, and if we have time to look on it again we shall see the wire thoroughly embedded in the ice. This practically illustrates my brother's theory of the plasticity of ice—according to which one side of the wire presses into the ice, and in pressing cools it. The ice and the water coming together on the one side give rise to freezing on the other. But there is another and more complex case in which we have stress on the solid—a solid which if it melts will relieve itself from that stress. Such a solid relieves itself from stress by inter-molecular melting; and takes up the form free from stress by re-freezing.

In an investigation brought before the Royal Society of London last May by Dr. Main, it was stated that experiments made in the Engadine during February, 1887, with the temperature many degrees below freezing point, upon slabs of solid ice, showed that these yielded regularly as any other viscous body yields. Main's investigation gave perfectly definite results, though differing considerably with the temperature. Therefore, a bar of ice can be elongated. Take a bar of sealing wax; hang a weight to it, and it will yield. So a bar of cold ice several degrees below freezing point—in an atmosphere at least 8 or 10 degrees below freezing point—was found to elongate by one third per cent. per 24 hours; and the stress was 2 kilos. per square centimetre.

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So also look at the shoemaker's wax filling this model, which illustrates the principal features in the path of say a Swiss glacier: not warm, but cold as it is here now, it will keep yielding constantly from year to year; working its way down this precipice, through this gorge, down this next precipice, out through this hole, and ultimately falling over the edges. Although it is brittle, it goes on day after day, month after month, yielding. I am not aware if my audience knows, what everybody knew many years ago, that a sealed letter left a long time seal down, flattens the seal with its own weight. We were always warned in those days not to seal letters for the tropics. Thus if you give it time enough, you will find the wax (alluding to the former model glacier) yielding, yielding, and yielding, according to the same laws, precisely as this mass of wax has yielded, aided by heat, in ten minutes—only with years instead of minutes. It would have taken months, I believe, instead of minutes, for an ordinary ball of shoemaker's wax to flatten in this way, if it had not been hurried by heat. We have made a calculation of this, but I will not go into the dynamics of the matter. There is, however, a distinct principle upon which you may calculate the equilibrium.

Turn again to this model showing the flattened ball: you may imagine this semi-fluid wax pulled in all round, held in as it might be by the sides of a containing box. Well it would then just take its level as water would. Now imagine the box placed in water and the sides taken away: the effect would be the same as if the wax were drawn out all round. There is no limit to the extent to which it would flatten itself, provided you did not keep adding material. But if you keep adding material, you arrive at a certain definite thickness. Suppose that to be a quantity of ice that covers a large area, and all of uniform thickness. How is this uniformity to be preserved? A great island covered with ice, 5 ft. thick and 10 miles across, with snow falling on it: at what rate must the snow fall upon it to keep its thickness uniform? Taking the calculation of viscosity of ice from Main's experiment, I find that ice 10 metres thick would require 33 centimetres per annum to fall upon it, to keep it of equal thickness. A metre is 39·37079 inches, or say 40 inches. The rate at which snow must fall upon ice 10 metres thick so as to keep its thickness uniform, would be 33 centimetres per annum. Double the thickness, or treble it, and you would require an increased snowfall to preserve it uniform—double

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thickness requiring a quadruple fall, and so on. Thus if you assume a snowfall four times the amount stated, you would only get double thickness. So that if the thickness of the ice depended solely on its viscosity, you may say that, between reasonable limits as to amount of snowfall, the floating ice on the Arctic Sea could not be thicker than from 10 to 20 metres; that is to say, 10 to 20 yards = 30 to 60 feet. That is about the thickness that it can be, if there is nothing whatever carrying it away.

In the Arctic Ocean such an ice sheet might go on extending till it came to the shores, and then it would go on getting thicker and thicker, when it might make an Arctic ice-cap like the Antarctic ice-cap. But there is great difference of opinion in respect to the abstraction of ice. In the present condition of the Arctic Ocean there is an enormous abstraction of ice, with the Gulf Stream flowing in here (Fig. 5), and shooting away past Norway, and even carrying trees through the region of the North Pole. You may depend upon it that under the surface the ice is being simply washed away, and so kept down to 20, 30, or 60 inches in thickness. As I have said, Captain Markham's expedition found it only 64 inches thick within 399 miles of the North Pole, and we have no reason to believe that it is anything thicker, or very much thicker, at the very Pole. The free circulation through the Arctic basin is certainly what keeps down the thickness of the Arctic floating ice just now.

Suppose the circulation were stopped by a barrier running across from Norway by Iceland to Greenland, the result would be that the circulation of the water from the rest of the ocean into the Arctic Sea would be stopped and the ice would spread out. The whole ocean would be cooled down to freezing point, and then the ice would thicken, the average temperature being far below freezing point. The mean annual temperature within the Arctic circle is 10 degrees (Fahrenheit). Mr. Buchan has kindly prepared for me an estimate of the temperature, which I shall read.

"Mean annual temperature within Arctic circle, as a whole, is 10° F. Pole of cold appears to lie in about lat. 84° N., long. 150° W., around which an area of over 6,000 square miles has a temperature of − 5° F. Two smaller centres of low temperature—one over Siberia about lat. 72° N., long. 123° E., and the other in North America, lat. 73° N., long. 105° W., over Melville Sound. Each of these centres has a temperature slightly below 0° F.

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"In January the centre of the main low temperature area is in almost the same position as shown on the annual map. The lowest temperature shown is – 35° F., and this iso-thermal includes an area of nearly 2,000,000 square miles. The subsidiary centre over Melville Sound also shows a temperature of – 35° F., and is in the same position as on the annual map. That over Siberia is farther to south and east, being now over Werchojausk, lat. 67° N., long. 134° E., and is of great intensity, the mean January temperature of Werchojausk, taken over four years, being – 60° F.

"In July the lowest observed mean in the polar area is 35° F. No separate areas of low temperature appear, the coldest region to the north of Asia being in the Kara Sea, east of Nova Zembla. Low temperatures, 30° F. to 35° F., persist over Melville Sound, probably on account of the southerly direction of the ice-drift."

Under this condition it is perfectly clear that if the circulation of water from the rest of the ocean into the Arctic Sea were stopped, that sea would get filled up with solid ice, which would get thicker and thicker until we should have a prodigious ice-cap in the northern polar regions. We don't know if there was ever such a thing; but I hope geologists will find it out, and I see no reason why their ingenuity, and their skilful and laborious scrutiny of palæo-historic monuments, should not discover it.

Let us consider now for a little the state of matters at the South Pole. Just imagine this to be ice—this black line to represent the boundary of the ice. It has been intimated that at certain parts the Antarctic ice-cap terminates in precipices of 170 to 200 feet in height. Mr. Croll's calculation is invalid beyond a certain limit, because it has been made on the supposition that the slope is uniform from the shore line inwards. He estimates that at the South Pole the thickness of the ice-sheet would be 12 miles. I say the slope cannot be uniform, and the reasoning, dependent on the assumption of uniform slope, must be fallacious.

Let us look at the realities of this Antarctic Continent in the light of what we know regarding the viscosity of ice. Through the kindness of Mr. Murray of the *Challenger*, I am enabled to place before you this splendid map (from which an outline sketch is given in Fig. 7). You see here Victoria Land, explored by Sir James Ross. We have here high mountains running up to a height of 8,000 feet, and a volcano, Mount Erebus, 12,000

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feet high—also discovered by Ross. There is an ice-barrier running 200 miles towards the west, which is everywhere about

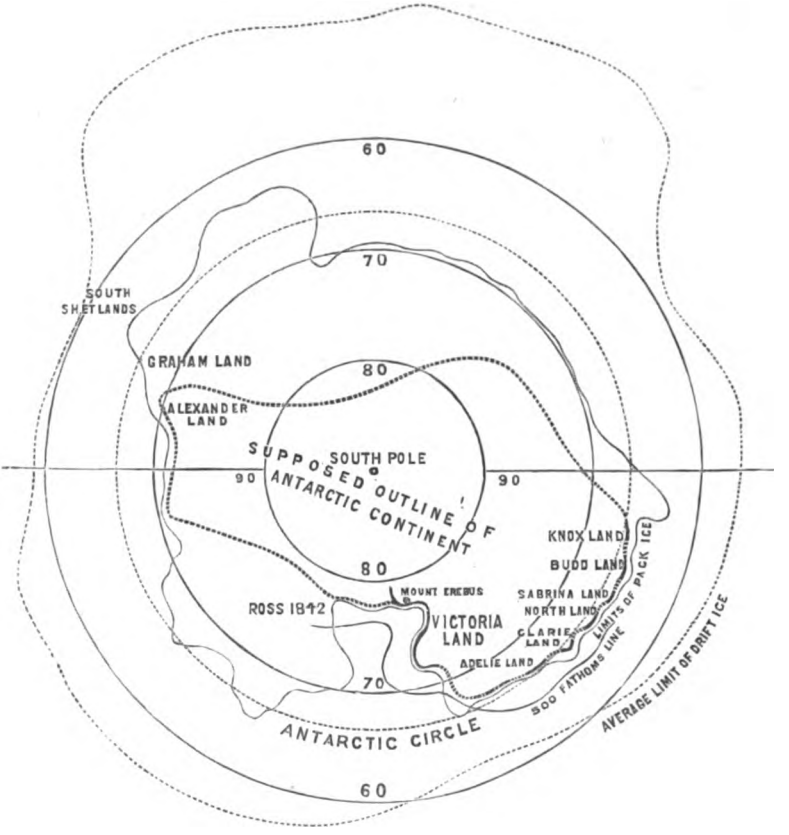

Fig. 7.

170 or 200 feet high above the sea. Here it is in our *model* Antarctic Continent already referred to. We break a piece off and thus we send an iceberg away. There is an ideal bay and gorge; a great high line, and ice slipping down into the water, and eventually breaking off, with ice below water nine times more than ice above it. It breaks away when it is ice borne and when it is water borne it will not break away. There [showing a sketch of an iceberg] is an ice precipice 170 feet above, and below 1,530 feet; and

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here is the *Challenger* in a snow storm just after she has broken her jib-boom on the iceberg. The soundings taken here are described as giving 264 fathoms—just deep enough to float out one of these huge icebergs—at least they won't need to crawl along the bottom of the sea, if the neighbourhood of the shore there, is anything like the neighbourhood of the shore elsewhere. In some places you get a depth of 250 fathoms very close to the shore, but this sounding may be about 100 miles from the shore. In ordinary water the ice will float out; when it gets into water deep enough it will break off. Now let us take Mr. Murray's estimate of snowfall—75 centimetres per year (I am sorry I must give you results not always in metres or centimetres: easy things made difficult is the result of the English system of weights and measures)—which is worked out in an elaborate manner, founded upon the observations of expert German observers at South Shetland, just within the Antarctic circle. This would be something like 4 feet of snow and rainfall. I find, then, that with the viscosity taken from Main's observation, the thickness of the ice sheet at the South Pole would be 5,300 metres, that is about 18,000 feet. It is a very considerable thickness—about 3 miles—but only a quarter of Croll's estimate, which is much too high. The ice could not possibly stand at a height of 12 miles.

Questions as to the possible effect of this Antarctic ice sheet, or of changes in respect to its thickness, would be much too serious for me to enter upon just now. There are just two or three points I would like to consider. The amount of viscosity, and the probable slope of the Antarctic Continent, seemed to show that the ice cannot be very much thicker than 2,000 or 3,000 feet, and not nearly so much as 5,000 metres, as I have indicated—though I don't say that such is impossible at the South Pole, but only that it seems improbable. It is, however, quite possible that the absolutely different view taken by Mr. Croll may be true. It is also possible that the land may slope up to the South Pole, so that there may be no ice at all upon it. We really do want to know something about the South Pole. A memorial was, as you will remember, sent to Government asking them to assist in equipping an Antarctic expedition. The request has not been granted, but I think we may expect that Government will yet see their way to it. We are encouraged all the more, because we are assured it would be much easier to drive a hansom up the hill of the

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South Pole than up the hill to our University. The hill of the South Pole is, in all probability, not more than a quarter of a degree, so that one could easily drive up it. Ross believed that if he could have found winter quarters there he could have walked over the Pole. If you once get ships up to the coast there (pointing to the chart) where Ross was, and get them comfortably frozen in, I don't see that there can be much difficulty in arriving at the South Pole.

Among the first questions to be ascertained is, Whether there is bare rock or ice at the Pole, and what may be the effect of underground heat there? It is quite possible that the solid rock may slope up to a mountain, and not be covered with snow at all. I think it is covered with snow; but there may also be bare crags, as in regions where snow cannot lie, and by boring into them something may be learned of the underground temperature. If we bore down a few thousand metres and find an increase of temperature at the rate of one degree centigrade per 27 metres, we may infer that it has been the same for many hundreds of years: if we find that the increase is smaller, we may be pretty sure that there has been a gain of ice; but if there is an increase of temperature of more than one degree we may infer an opposite state of things—that there has been melting, and that we are in a period subsequent to the melting. But take this case. Suppose the state of affairs to have been steady for about 5,000 or 10,000 years, or some little time like that, with an ice-cap 2,000 feet thick—and it is not at all improbable that that is the present condition—and suppose that under some of Croll's astronomical changes the sun became colder, and that snow began to fall twice as fast as now, and that it went on snowing for 2,000 years, the result would be that there would be a gain at the rate of, in round numbers, 2 feet per annum for 100 years—twice as fast as at present for 1,000 years. Set off against that the sloping down, and you get a very complicated problem. The terrestrial temperature would not follow it up. It would go for nothing. The thermal conductivity may be expressed thus:—How much heat would be conducted per annum through the 27 metres of rock? You can make a calculation, remembering that there are 31½ million seconds in a year. The temperature increases by one degree centigrade per 2700 centimetres, and the thermal conductivity of average

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rock (in centimetre-gramme-second units or "c.g.s.") is ·005. Thus we have the calculation :—

$$\frac{31\frac{1}{2} \times 10^6}{2700} \times \cdot 005.$$

The result is about 6 gramme centigrade units of heat per annum. Now it would take about 79 such units to melt a centimetre of ice per annum. So that is all underground heat would do ; in other words, it would go for nothing in respect to retarding the increase of the ice-cap. This shows that if we were to have this change of temperature and this double snowfall for several hundred years, there would be a very sensible addition to the quantity of ice, and a very sensible depression on the water elsewhere. But if the Antarctic ice-cap were to be greatly increased it would lower the water, diminish the circulation, and tend to cool the Arctic Ocean. Therefore, from this consideration alone, we should expect glaciation in the northern hemisphere simultaneously with an augmentation of the Antarctic ice-cap.

But by far the most potent influence for altering the climate in any part of the world is oceanic circulation. The sea is the great carrier of heavy goods. Our atmosphere of air, with its pressure of fifteen pounds per square inch, corresponds to 33 feet of sea. A column of sea-water 33 feet long (or 10 metres, or $5\frac{1}{2}$ fathoms) and square inch area, weighs 15 lbs. The atmosphere, mass for mass, is just equivalent to $5\frac{1}{2}$ fathoms of sea, but 33 feet depth is a mere fraction of our sea-water. And again, a quantity of water is of much greater capacity for heat than the same quantity of air, the thermal capacity of air being very much less than that of water. Briefly then we may say that in the transport of heat over the whole solid globe the air goes for nothing. The sea is the great carrier. The air, of course, has an enormous indirect effect in the shape of gales, moderate winds, or trade winds, and in moving the water. It moves the surface of the water just as it moves the ships over the water. So that wind, indirectly, helps the sea as a heat carrier. The air, however, *distributes* the heat carried by the sea, and in this connection we may remember with the clergyman that there is no use praying for fine weather until we have a change of wind. The wind is the distributer, the sea is the carrier—the great carrier—in the transport of heat.

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Additional Note to Mr. Bell's Papers.

[See Nos. XXI. and XXII., pp. 237-261.]

Instances of the longer axis of the boulders coinciding with the direction in which these rocky fragments have been transported are, as has been said, sufficiently numerous to be noted in the Reports as the general or normal position. But it is to be borne in mind that exceptions are also numerous, though these have not been so particularly recorded.

Recent observations during a brief visit to a number of the Swiss glaciers may for the present be summed up as follows:—

1. There is no absolute uniformity in the positions of the boulders carried down by these glaciers; nor, indeed, when the conditions are considered, should this be looked for.

2. On short glaciers, especially, and where the ice is much broken and crevassed, there is the greatest diversity of position.

3. But on the longer glaciers, and where the ice is for some distance comparatively smooth and unbroken, the prevailing—almost uniform—direction of the boulders is undoubtedly longitudinal, or parallel to the course of the glacier.

A large proportion of the stones in the lateral and terminal moraines—more than was apparent at first sight—have the same general direction. One might say this was chiefly the case as regards the larger boulders; but this impression might be due simply to these being the more conspicuous.

Further observation on these points is suggested as desirable.

Meantime we have little or no doubt, from what we have seen, that the tendency of boulders on all glaciers is to assume a longitudinal position, and that this is most observable, as might be expected, on the larger glaciers, where the obstructions are fewer in proportion to the mass, and produce the least disturbing effect.

D. B.

Oct., 1888.

*** Of the Boulders figured in Plate V. No. 1 is after a photograph for which we are indebted to Mr. Lumsden of Arden, No. 2 is from a sketch kindly taken by Mr. M'Oran Campbell.

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PROCEEDINGS FOR SESSION 1886-87.

(29TH SESSION.)

SOCIETY'S ROOMS, 207 BATH STREET, 14TH OCTOBER, 1886.

Mr. JOHN YOUNG, F.G.S., *Vice-President*, in the Chair.

Mr. ROBERT DUNLOP exhibited specimens of *Aviculopecten papyraceus*, Goldfuss, *Orthoceratites*, sp., and other marine fossils, which he had lately discovered in the Upper Coal measures, at Calderbank, Airdrie, the horizon lying between the Kiltongue and Virtuewell Coals—a most interesting find—going to prove that certain thin layers in the Upper Coal series had been laid down under marine conditions. Remarks were made by the Chairman, who pointed out that similar thin marine bands had been recorded elsewhere from the Upper Coal measures of Lanarkshire, and from the Coalfields of Fife and of England, proving the presence of the sea over these areas during short intervals of time during the deposition of the strata of the Upper Coal measures. Mr. James Thomson, F.G.S., stated that in his belief there was no proof that these shells, though of marine origin, had been deposited in these beds under any conditions but fresh water ones.

The CHAIRMAN exhibited slabs of Carboniferous Limestone Shale, covered with markings of Dendritic "Wad" or Black Oxide of Manganese, from Nettlehirst Quarry, Barrmill, Ayrshire, and spoke of their occurrence and origin.

Mr. JAMES WHITE read a paper entitled "Notes from Glencoe," which was illustrated by a map of the district and a number of rock specimens. Some discussion on points raised in the paper ensued.

ANNUAL GENERAL BUSINESS MEETING, 11TH NOVEMBER, 1886.

Mr. WILLIAM JOLLY, F.G.S., *Vice-President*, in the Chair.

The HON. SECRETARY (Mr. Murdoch) read the Report of the Council for the past year, as follows:—

REPORT OF THE COUNCIL FOR 1885-86.

The Council of the Geological Society of Glasgow have once more pleasure in submitting to members their report upon the work of the past session, the 28th of the Society's existence.

MEMBERSHIP.—Your Council regret to say that the additions to the roll

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did no more than balance the losses from death, and withdrawal (chiefly by members leaving the district), although last October a special circular asking each member to do his best to find at least one new member was circulated. It is evident that the total membership is by no means so large as the position and work of the Society warrant, and a special circular has again been sent out this year, in the hope that it will induce members to exert themselves to add new names to the roll. Life members are also wanted.

FINANCES.—From the report to be submitted this evening by your Hon. Treasurer, it will be seen that while the income of the Society has hitherto been sufficient to pay its way, and leave a surplus, there have been extra expenses during the year, and that an addition to the funds would be very welcome.

MEETINGS.—Nine ordinary meetings were held during the winter and spring months, and were attended by about the usual average of recent years —about 50—above a fourth of the membership.

By the kindness of Dr. Foster Heddle, of St. Andrews, two special meetings were held in the Large Hall of the Philosophical Society, in May, when he delivered a lecture on "Carbonic Acid in Nature, as evidencing design." Numerous illustrative chemical experiments were given, the required apparatus being furnished by the kind assistance of Dr. William Wallace, City Analyst, and Messrs. Baird and Tatlock, Chemical Dealers, Sauchiehall Street.

PAPERS.—Of the papers read at the meetings, several were of considerable importance and interest, while many specimens, usually accompanied by notes or remarks, were brought forward. Indeed, had time permitted, these remarks, and also some of the discussions upon papers read, might have profitably assumed larger proportions.

Of the papers may be named the following:—"Tarbert in Lochfyne," by Mr. James White; "Account of the Joint Excursion of the Edinburgh and Glasgow Geological Societies to Ben Nevis and the Parallel Roads of Glenroy, in July, 1885," by Mr. William Jolly, F.G.S., *V.P.*; "The Life and Palæontological Work of the late Dr. Thomas Davidson, F.R.S., of Brighton," by Mr. John Young, F.G.S., *V.P.*; "On Crystallization and Liquefaction, as influenced by Stresses in the Crystals, with special reference to Metamorphic Changes in Rocks, and Plasticity of Ice," by Prof. James Thomson, LL.D., F.R.S.E., etc., University of Glasgow; "Notes on the Carboniferous Brachiopoda of Scotland," with a revised list of the genera and species, by Mr. John Young, F.G.S., *V.P.*; "The Detached Areas of Carboniferous Deposits in Scotland," by Mr. Dugald Bell; "On the Succession of Rocks in the N.W. Highlands,—the problem, its history and present state," by Mr. William Jolly, F.G.S., *V.P.*; and "The Geology of Annandale," by Dr. J R. S. Hunter, F.R.Ph.S.E., *Hon. Member.*

The EXCURSIONS of the Spring and Summer were generally very success fully carried out, and were well attended on the whole. The list is as follows:—

Cathkin, 17th April, 1887, conducted by Mr. Walter Burns.
Paisley and Gleniffer, 1st May, conducted by Mr. M. Blair.

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Gourock, 15th May, conducted by Mr. William Armour.
Barrmill and Kilwinning, 27th May, conducted by Mr. John Smith.
Torbanehill and Bathgate, 12th June, conducted by Mr. R. R. Horne.
Bowling and Auchentorlie Glen, 26th June, conducted by Mr. John Young, F.G.S., *V.P.*

At Cathkin, the volcanic tuffs of which Mr. Young had not long before told us in his paper on their occurrence in this horizon, were more particularly examined, and the pleasant afternoon was wound up by a visit to the hospitable residence of Mr. James Tullis, at Burnside.

At Gleniffer, several good photographs of the party, having the Carboniferous Limestone cliffs as a background, were taken by an amateur, with fine effect.

At Gourock, the works for the new Caledonian Railway from Greenock were inspected and thoroughly examined, through the kindness of Provost Kennedy, of Partick, the contractor.

From Barrmill, the members proceeded to Kilwinning, through the Lower Limestone strata, exposed in the cuttings for the new Lanarkshire and Ayrshire Railway.

At Torbanehill, the pits, where the last remaining portions of the famous mineral are now being worked, were visited jointly with the members of the Edinburgh Geological Society, the party afterwards dining together in the Royal Hotel, Bathgate, on the invitation of Mr. R. R. Horne, lessee of the workings.

On the last excursion—that to Bowling, etc.—Mr. Young conducted the party over ground classic to members of the Society, but not visited by them for many years previously.

As in 1885, an extended excursion, jointly with the members of the Edinburgh Geological Society, was planned for the last week of July, to visit Loch Maree and district, under the guidance of Mr. William Jolly, F.G.S. Many of the disputed points in the succession of the N.W. Highland rocks were visited and examined, and all those who had been fortunate enough to accompany the party, pronounced it to be a great success. It is to be hoped that these long excursions, so happily inaugurated by those which have already taken place, may be continued in future years.

The Library.—From the untiring work of the Hon. Librarian, Mr. James White, the Library has now assumed an aspect which it never before wore. A catalogue has been printed and circulated, and it is expected that members will now make an extended use of the stores of geological literature within their reach.

The Transactions.—Part I. of vol. VIII. is now all in type, and will, it is safe to say, be in the hands of members by next meeting. It contains most of the papers read during the last two sessions, and also a record of the Proceedings, so that for the first time for many years, the issue of the *Transactions* may be said to be up to date. The Council believe that this position, once attained, will not be allowed to be departed from, as early publication of papers in a Society such as ours is of primary importance.

Death and Withdrawal of Members.—At the first meeting of last

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session, Mr. James Coutts read a notice of his lately deceased friend Mr. Andrew Patton, of East Kilbride, a corresponding member of the Society, and within a few short months Mr. Coutts himself has been summoned to join the great majority. A notice of Mr. Coutts, read by Mr. John Young, F.G.S., will be found in the new part [Part I., Vol. VIII., page 177] of the *Transactions*. A well known and long-continued member of the Society, Mr. John Dron, died during last summer. Owing to the fact that he had gone to reside permanently at Millport, Mr. David Robertson, F.L.S., F.G.S., resigned his membership, and the Council have therefore unanimously agreed to recommend that he should be elected an Honorary Associate.

J. B. MURDOCH, Hon. Secretary.

The HON. TREASURER (Mr. John Wight) read as follows:—

FINANCIAL REPORT FOR 1885-86.

Income is a little less than it was last year, being then £99 8s. 5d., and now £92 2s. 7d., or £7 5s. 10d. against the year 1885-86, arising from fewer new members being elected, and less arrears recovered. The members who paid subscriptions this year were 161, against 168 the year preceding. The difference is not very considerable, and experience has shown that the Society can count upon a membership of at least 150, without much fluctuation. The accounts are so plain that they require no particular explanation or remark. The ordinary expenditure has cost about two-thirds of the subscription revenue, leaving at least £25 a year from subscriptions and £10 or £12 from other sources to be applied to expense of printing *Transactions*. The Treasurer has looked into the Accounts for the last fifteen years to find the cost of ordinary expenditure during that period, and he has ascertained that it averages £50 13s. 11d., so that the observations just made seem to be sufficiently well supported. The property of the Society is stated this year at £465 4s. 9d., only £10 less than a year ago; but the collection of geological specimens, which has been valued for some years at £18, has now been entered at *nil;* so that the Society's stock has not diminished, but somewhat increased, during the past twelve months.

JOHN WIGHT, Hon. Treasurer.

The HON. LIBRARIAN (Mr. James White) then read as follows:—

REPORT ON THE LIBRARY FOR 1885-86.

In offering you my second Report as Librarian, I am pleased to be able to state that the confusion and disorder, which formed so marked a feature in the Library a year ago, have now passed away, and have given place to a more tidy state of things. Even the Augean stable down stairs has been cleaned up and presents a fairly neat and respectable appearance. This has not been accomplished without a good deal of labour and a good deal of money. I don't grudge the labour, and I hope no one grudges the money—so we shall be quits.

If the expenditure has been large, full value has been got for it. All arrears of bookbinding have been overtaken, and there is not a sheet in the premises up stairs or down which has not been examined and the utmost

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made of it. Some publications are still incomplete, from the missing numbers being out of print, but otherwise every imperfect book has been completed and bound.

The bookcase down stairs has been altered to make it more commodious. We have secured from the Philosophical Society the use of one half of the commodious bookcase which stands at the end of the council room, and have altered it to suit our own purposes, so that we have now accommodation sufficient to permit of the extension of the Library, at its present rate of growth, for several years to come.

A new Catalogue has been printed and issued, and will, it is hoped, considerably assist members in the use of the books; and an interleaved copy, in which all new books are immediately entered, lies on the table.

Now that we are in a fair way of doing well, no such expenditure as has been incurred this year need again be necessary, provided that a sufficient sum of money is granted and spent annually in keeping things in order. Serial publications and Transactions of Societies must be bound and placed in the shelves as they are completed, or else "the last state" may become, if not "worse," as bad as "the first." New books must also be added to keep us abreast of the times.

For these purposes, as last year's expense has been so great, and as a considerable number of new books have lately been added, a grant of £5 for this year will probably suffice.

JAMES WHITE, Hon. Librarian.

The Reports were all unanimously approved of, and on the motion of Mr. David Forsyth, M.A., the Hon. Secretaries, Treasurer, and Librarian were awarded a hearty vote of thanks for the services they had rendered to the Society during the past year.

The following gentlemen were elected to fill the vacancies in the Council occurring at this date:—As Vice-President, Mr. Daniel M'Millan; as Members of Council, Messrs. John Young, F.G.S., Robert Dunlop, John Dougan, and John Howat.

Messrs. John Robertson and David Pearson were elected auditors for the ensuing year.

The following gentlemen were elected Ordinary Members of the Society:—Mr. John A. Burns, 42 Virginia Street, and Mr. Robert Guy, writer, The Wern, Pollokshaws.

Mr. WALTER BURNS exhibited, with remarks, specimens of a Fish Palate, and of *Lingula squamiformis*, from the Carboniferous shales of Burnibrae, Milton of Campsie, the horizon of strata there exposed being that of the Campsie and Hurlet series.

Mr. JOHN YOUNG, F.G.S., made some explanatory remarks upon the appearance and differences of Vein quartz and Quartzite, in regard to which there appeared to be, he said, no little confusion.

A number of Rock specimens were shown under the Society's and other microscopes kindly lent for the occasion by members. Mr. Joseph Sommerville took charge of the arrangements, and the many beautiful sections were much appreciated by the members present.

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SOCIETY'S ROOMS, 207 BATH STREET, 9TH DECEMBER, 1886.

Mr. D. C. GLEN, F.G.S., *Vice-President*, in the Chair.

The following gentlemen were elected members of the Society:—

As Honorary Associate, Mr. David Robertson, F.L.S., F.G.S., Millport.

As Ordinary Members, Rev. Robert William Dobbie, 21 Hamilton Park Terrace, Hillhead; Mr. William Murray, Coalmaster, 148 Hill Street, Garnethill; Rev. W. W. Tulloch, Knowe Terrace, Pollokshields; and Mr. Andrew Wright, 3 Moray Place, Strathbungo.

Mr. WILLIAM JOLLY, F.G.S., exhibited a number of Bones of the Moa from New Zealand, and read a series of interesting notes upon the occurrence of the remains of this extinct bird. Mr. John Young, F.G.S., Mr. D. C. Glen, F.G.S., and Mr. Murdoch also spoke on the subject.

Mr. JOHN YOUNG, F.G.S., read a paper on "The Composition and Modes of Occurrence of Crystalline Quartz, Vein Quartz, and Quartzites" [see page 278], illustrating it with sectioned slides for the microscope. The discussion which followed was taken part in by Messrs. Jolly, F.G.S., Bell, Sommerville, and Glen, F.G.S.

SOCIETY'S ROOMS, 207 BATH STREET, 13TH JANUARY, 1887.

Mr. DANIEL M'MILLAN, *Vice-President*, in the Chair.

Messrs. John Gardner, Quarrymaster, Ballachulish, and 21 Clyde Place; Andrew Brown, 21 Roselea Drive, Dennistoun; and John Main, F.G.S., Partick, were elected Ordinary Members of the Society.

Mr. ROBERT CRAIG, Langside, Beith, *Cor. Mem.*, read a paper on "The Horizons of the Mammoth Bed of Kilmaurs and Dreghorn, Ayrshire." [See page 213.]

Remarks on the subject were made by Messrs. John Young, F.G.S., James Steel, Adam Knox, Dugald Bell, and others.

Mr. JAMES ANDERSON read a paper on "Glaciation and Raised Beaches in Islay and Jura." [See page 316.]

Some discussion followed, and was taken part in by Messrs. Dugald Bell, John Young, F.G.S., Sommerville, and other members.

SOCIETY'S ROOMS, 207 BATH STREET, 10TH FEBRUARY, 1887.

Mr. WILLIAM JOLLY, F.G.S., *Vice-President*, in the Chair.

Messrs. Thomas Richmond, L.R.C.P.E., Surgeon, 26 Burnbank Terrace, and William Sinclair, Grange, Bothwell, were elected Ordinary Members of the Society.

Mr. ROBERT DUNLOP exhibited a specimen of *Glyptoscorpius* from the Upper Coal measures at Mount Vernon, Lanarkshire. Mr. John Young, F.G.S., noted some of its peculiarities, and said the specimen was in a

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measure unique in character, from its great rarity and fine state of preservation.

Mr. JOSEPH SOMMERVILLE exhibited a series of Rock specimens from Canada, including examples of Laurentian Gneiss, Granite, Limestone, Apatite, Mica, Serpentine, Strontianite, etc.

Mr. JAMES STEEL, on behalf of Mr. Thomas Scott, *Corresponding Member*, read a paper entitled "Some Notes on the Geology of the District around Tarbert, Lochfyne." [See page 262.] The paper was illustrated by specimens of the rocks referred to. Mr. John Young, F.G.S., made some remarks on the subject.

SOCIETY'S ROOMS, 207 BATH STREET, 10TH MARCH, 1887.

Mr. D. C. GLEN, F.G.S., *Vice-President*, in the Chair.

Mr. John Fowler, 4 Kelvinbank Terrace, Gray Street, Sandyford, was elected a Life Member, and Mr. James E. Sommerville, B.D., Minister of the Gospel, 11 Southpark Terrace, Hillhead, was elected an Ordinary Member of the Society.

Mr. JOHN SMITH exhibited a number of Volcanic Bombs, which he had taken from a bed of ash, twenty feet thick, exposed on the banks of the Duisk Water, near Dalry, Ayrshire.

Mr. WILLIAM JOLLY, F.G.S., *V.P.*, read a paper on "The Geology of Loch Maree and Neighbourhood," with reference to the controversy on the Succession of the N.W. Highland Rocks, with an account of the Joint Excursion by the Members of the Edinburgh and Glasgow Geological Societies there in July, 1886." The paper was illustrated by a large series of maps, diagrams, and specimens of the typical rocks of the district. At its close remarks were made by Rev. W. W. Tulloch, Messrs. John Young, F.G.S., Dugald Bell, Murdoch, and others, several of whom had taken part in the excursion referred to.

SOCIETY'S ROOMS, 207 BATH STREET, 14TH APRIL, 1887.

Mr. D. C. GLEN, F.G.S., *Vice-President*, in the Chair.

Mr. JOHN YOUNG, F.G.S., and Mr. ROBERT MASON, F.L.S., exhibited mounted specimens of a small Stalked Crinoid, *Allegecrinus Austinii*, from the Lower Carboniferous Limestones of Howood, Renfrewshire, and Auchenskeoch, near Dalry, some remarks on the species and the localities where it was found being made by the former.

Mr. D. C. GLEN, F.G.S., *V.P.*, exhibited a number of fine specimens of Trilobites from Silurian and Carboniferous strata.

Mr. J. B. MURDOCH, *Hon. Sec.*, exhibited specimens of Sandstones and Sandy Shales from the cuttings of the new branch of the G. and S. W. Railway near Greenock, which showed induration from the action of pressure and heat, and subsequent decomposition, and upon which further remarks were made by several members.

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Mr. G. G. HENDERSON read a paper entitled "Description of an uncommon dark brown Carbonaceous Sandstone" found in the neighbourhood of Tweed River Heads, Australia. [See page 276.]

In the absence of Dr. J. R. S. HUNTER, *Hon. Member*, Mr. J. B. MURDOCH, *Hon. Sec.*, read a paper entitled "Notes on Ancient Workings in the Ell Coal near Wishaw, Lanarkshire." [For an abstract see p. 315.] Some discussion ensued, and the members who spoke did not seem to think the author had proved his theory that the workings described were Roman. The great probability was that they were of a much more recent date.

SOCIETY'S ROOMS, 207 BATH STREET, 12TH MAY, 1887.

Mr. DANIEL M'MILLAN, *Vice-President*, in the Chair.

Mr. John Boyd, one of H.M. Inspectors of Schools, 9 Princes Square, Regent's Park, was elected an Ordinary Member of the Society.

Mr. DUGALD BELL read a paper "On the Glacial Phenomena of Scotland, with reference to the Reports of the Boulder Committee of the Royal Society of Edinburgh." [See page 237.]

An interesting discussion followed and was taken part in by Messrs. James Thomson, F.G.S., John Young, F.G.S., William Jolly, F.G.S., David Forsyth, M.A., and other members.

SOCIETY'S ROOMS, 207 BATH STREET, 26TH MAY, 1887.

Mr. WILLIAM JOLLY, F.G.S., *Vice-President*, in the Chair.

Mr. J. F. Bryden, 26 Shamrock Street, was elected an Ordinary Member of the Society.

Mr. ROBERT DUNLOP exhibited a specimen of a large Scorpion-like Crustacean from the Lanarkshire Upper Coal measures. It seemed to be entirely new to science, and having been placed in the hands of Mr. B. M. Peach, Geological Survey of Scotland, it was hoped he would figure and describe it for the *Transactions* of the Society.

Dr. J. R. S. HUNTER, F.R.Ph.S.E., *Hon. Member*, read a paper entitled "Volcanic Action and Earth Movements in the Upper Coal Measures of Lanarkshire." In this paper the author brought forward numerous examples of the great dislocations and faultings which had been from time to time observed in the rocks under notice, illustrating his observations and deductions by a large series of maps, sections, and specimens of local volcanic products.

Some discussion followed, and was taken part in by Mr. John Young, F.G.S., and several other members.

The CHAIRMAN then declared the 29th session of the Society to be closed, expressing a hope that the members would meet with renewed health and vigour to inaugurate another year of the Society's work in October next.

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PROCEEDINGS FOR SESSION 1887-88.

(30TH SESSION.)

SOCIETY'S ROOMS, 207 BATH STREET, 13TH OCTOBER, 1887.

Mr. D. C. GLEN, F.G.S., *Vice-President*, in the Chair.

The CHAIRMAN congratulated the members on the opening of the 30th session, and hoped that in the future, as in the past, the Society would do good geological work.

Mr. ROBERT DUNLOP exhibited specimens of Crustacean remains from the Lanarkshire Upper Coal measures, including *Anthropalæmon Grosartii*, Salter, first discovered by, and named after, the late Dr. Grosart of Salsburg, parish of Shotts, long a corresponding member of the Society. The present specimens had been found in the shale overlying the ironstone, the stratum being apparently quite local, extending to at the most four miles, and at its broadest about four hundred yards. Remarks on the specimens were made by Mr. John Young, F.G.S., Mr. James Thomson, F.G.S., and others.

Mr. JAMES WHITE read a paper entitled "A Glimpse of Loch Maree, with Notes and Thoughts by the Way," and some discussion on various points raised in the paper followed.

SOCIETY'S ROOMS, 207 BATH STREET.

ANNUAL GENERAL BUSINESS MEETING, 10TH NOVEMBER, 1887.

Mr. WILLIAM JOLLY, F.G.S., *Vice-President*, in the Chair.

The HON. SECRETARY (Mr. Murdoch) read as follows :—

REPORT OF THE COUNCIL FOR SESSION 1886-87.

The Council have again the pleasure of submitting their Annual Report upon the business of the past session—the 29th in the Society's history—and they are happy to be able to say that the work has proceeded evenly and prosperously, but without anything of an eventful nature to chronicle.

The MEMBERSHIP has remained almost stationary, the number of names on the roll, though reduced on the one hand by the various causes which operate in this direction, having been strengthened by the addition of new

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members. As the Council have frequently pointed out, the list might easily be enlarged, with considerable advantage to the Society and to all concerned. One Life Member was added to the roll during the year.

Of FINANCE it is more especially the province of your Hon. Treasurer to speak, and it will be found that he is able to report on the whole favourably of the situation in that respect.

The MEETINGS of the 29th session, nine in number, were taken part in by fully the regular average number of members, about forty, a fairly good attendance, considering the many counter attractions now open in Glasgow in the evenings.

The PAPERS and SPECIMENS submitted at the various meetings of the session were in many cases of high interest and importance. Amongst the former may be enumerated the following :—"Notes on Glencoe," by Mr. James White; "Quartz as a Rock-forming Mineral," by Mr. John Young, F.G.S. [see page 288]; "On the Post-pliocene Beds of the Irvine Valley, Kilmaurs, and Dreghorn districts," by Mr. Robert Craig, *Cor. Mem.* [see page 213]; "Some Notes on the Geology of the district about Tarbert, Lochfyne," by Mr. Thomas Scott, *Cor. Mem.* [see page 262]; "The Geology of Loch Maree and Neighbourhood, with respect to the controversy on the N.W. Highland Rocks, and an account of the Joint Excursion to the district by members of the Glasgow and Edinburgh Geological Societies in July 1886," by Mr. William Jolly, F.G.S., *V.P.*; "Volcanic Action and Earth Movements in the Upper Coal Measures of Lanarkshire," by Dr. J. R. S. Hunter, *Hon. Mem.*; "On the Glacial Phenomena of Scotland, with reference to the Reports of the Boulder Committee of the Royal Society of Edinburgh," by Mr. Dugald Bell [see page 237].

A number of these papers will be printed in the next part of the *Transactions*.

The EXCURSIONS during last season were well, and sometimes largely, attended, as they were arranged for localities easily accessible on Saturday afternoons. They were as follows :—

Giffnock and Orchard, Saturday, 16th April, conducted by Mr. James Anderson.

Barrhead and Arden, Saturday, 30th April, conducted by Mr. D. C. Glen, F.G.S.

Calderwood and Torrance, Saturday, 14th May, conducted by Mr. Dugald Bell.

Mugdock and Strathblane, Saturday, 28th May, conducted by Mr. John Young, F.G.S.

Inellan and Toward, Saturday, 11th June, conducted by Mr. William Jolly, F.G.S.

Kilbirnie and Beith, Saturday, 25th June, conducted by Mr. Robert Craig. (A joint excursion with the members of the Edinburgh Geological Society.)

An extra excursion was arranged for Balmaha, Lochlomond, on 2nd July, 1887, conducted by Mr. James Anderson, and was very successful.

No long excursion, like those taken in former years to Lochaber and to

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Loch Maree, was arranged for this summer, but it may now be stated that an extended trip to the Oban district during 1888 has been planned, and will probably be carried out.

The LIBRARY has been in full working order during the year, and has been well made use of, a great improvement in this respect being noticeable. The binding of books in parts has been brought up to date, but though the outlay under this head has been beyond that of any former year, that is counterbalanced by the condition of the library. The Council hope that the books will be still more used than they have been.

Of the TRANSACTIONS, no new part has appeared during the year, other expenditure having rendered it inadvisable to incur a new printing account. Arrangements are now being made to commence another part, which is expected to be in the hands of members at the close of the present, or the commencement of the following session.

LOSSES OF MEMBERS.—During the year now closed, several well-known names have been removed from the roll by death. By far the most outstanding of these is that of Professor de Koninck of Liège, the celebrated palæontologist, elected an Honorary Member in 1872, when he visited Glasgow, and was entertained to dinner by a number of the members. Prof. de Koninck's reputation was worldwide, and the Council hope that a notice of his life and work will be contributed to the Society during the current session. [See page 308.]

J. B. MURDOCH, Hon. Secretary.

The HON. TREASURER (Mr. John Wight, C.A.) then read as follows:—

FINANCIAL REPORT FOR 1886-87.

Subscription income in 1886 was £80 10s.; this year it is the same. In 1886 that sum included 11 new members and no arrears; in 1887 it includes 13 new members and 3 arrears: consequently the revenue from membership has remained stationary. The members who have actually paid subscriptions are 158, against 161 reported last year—a small decrease. The Treasurer reported last year that for a long time the average cost of the ordinary expenditure had been about £50. It will be observed that it has not exceeded, during the past year, £41 14s. 7½d. The debts of the Society are under £10, not taking into account the expense that may have been incurred for *Transactions*, if any, about to be distributed at the present time. The income from Invested Funds has been a few shillings less than last year. It will be noticed from these remarks that the ordinary financial business of the Society has been carried on as usual on a fairly economical basis, and though £80 of the Society's investments have had to be called up, it was not to meet any ordinary outlay, but to help to liquidate the cost of the *Transactions* and of printing the Catalogue, which together totalled £105 1s. 3d., £6 17s. being still unpaid. The Catalogue cost £23 7s. 6d., and it may be well to avoid this expense for a good many years to come. In regard to the *Transactions*, the Treasurer reported before, and he repeats it now, that arrangements should be made that the expense of the current *Trans-*

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actions and the ordinary expenditure should not, as a general rule, exceed the income of the Society for that year. The Accounts show that one Life Membership has been taken up.

JOHN WIGHT, Hon. Treasurer.

The election of office-bearers to fill the vacancies occurring in the Council at this time was then proceeded with, the following being the result :—

President, Sir William Thomson, LL.D., F.R.S., etc. ; Vice-President, Mr. Dugald Bell ; Members of Council, Messrs. D. C. Glen, F.G.S., Walter Burns, James Dairon, F.G.S., and James Thomson, F.G.S. ; Honorary Treasurer, Mr. John Wight, C.A. ; Honorary Librarian, Mr. James White ; Honorary Secretary, Mr. James Barclay Murdoch, F.R.Ph.S.E. ; Assistant Honorary Secretary, Mr. Gavin M. Pratt ; Auditors of Accounts, Mr. D. Pearson and Mr. Robert Gill.

Mr. William Dow, 165 Hospital Street, Glasgow, was elected an Ordinary Member of the Society.

Mr. JAMES S. M'LENNAN read a paper entitled "Notes on the Jordanhill Coalfield" [see page 271], and remarks on the subject were made by Sir James Bain, Mr. John Young, F.G.S., Mr. James Thomson, F.G.S., and other members.

Mr. D. C. GLEN, F.G.S., made some observations on the work of Section C. (Geology) of the British Association at the Manchester Meeting in September last, giving also a short account of some of the more interesting geological excursions then taken.

SOCIETY'S ROOMS, 207 BATH STREET, 8TH DECEMBER, 1887.

Mr. DANIEL M'MILLAN, *Vice-President*, in the Chair.

Mr. JAMES WHITE, Hon. Librarian, moved that £5 should be granted for the use of the Library, and this was unanimously agreed to.

The following gentlemen were elected members of the Society :—

As a Corresponding Member, Mr. Thomas Naismith, 6 Broompark Terrace, Dennistoun.

As Ordinary Members, Messrs. Alexander Bryson, 142 Trongate ; Andrew Meiklejohn, 52 Cromwell Street ; W. J. Millar, C.E., 261 West George Street ; James Miller, 1 Athole Terrace, Hillhead ; and Robert Mitchell, 24 Howard Street, Bridgeton.

Mr. JOHN YOUNG, F.G.S., read a paper entitled "Notes on the Carboniferous Genera of the Anatinidæ" [see page 291], which was accompanied by illustrative specimens.

Mr. DUGALD BELL, *V.P.*, read a paper entitled "Notes of the Society's Excursion to Calderwood Glen and Torrance Glen, East Kilbride, in May, 1887." After referring to the picturesque character of these glens, he described their more interesting geological features—the beds of sandstone, shale, coal, ironstone, and limestone exposed in them, and which were known as the Crossbasket ironstones and limestones—and by a sketch of

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the district he indicated their position as members of the lower limestone series. He enumerated the principal localities for fossils, paying also a high tribute to the early labours of the Rev. David Ure in the locality, and to the more recent and long continued investigations of Mr. Andrew Patton of East Kilbride, a corresponding member, also to those of the late Mr. James Coutts, long a member of the Society.

SOCIETY'S ROOMS, 207 BATH STREET, 12TH JANUARY, 1888.

Mr. DUGALD BELL, *Vice-President*, in the Chair.

Mr. D. C. GLEN, F.G.S., exhibited a number of mineralogical specimens, including a fine crystal of Stibnite from Japan, Amazonstone from Peaks Pike, Colorado, and Wolfenite crystals from Arizona.

Mr. JOHN KIRSOP exhibited a specimen of Bituminous Coal, showing flattened spheroidal structure, also a specimen of Obsidian from New Zealand, and various specimens from Egypt, upon which some remarks were made.

Mr. ROBERT DUNLOP exhibited a specimen of *Archithys sulcedens*, said by Dr. R. H. Traquair to be the only perfect specimen of this fish he had seen, it being usually represented only by its large laniary teeth.

Mr. DUGALD BELL, *V.P.*, read a paper "On some Boulders near Arden, Lochlomond." [See page 254.]

Remarks on the subject were made by Messrs. James Anderson, Steel, John Young, F.G.S., William Jolly, F.G.S., and other members.

SOCIETY'S ROOMS, 207 BATH STREET, 9TH FEBRUARY, 1888.

Mr. DANIEL M'MILLAN, *Vice-President*, in the Chair.

Ex-Provost Clark, Paisley, and Mr. Thomas Sinclair, 206 New Dalmarnock Road, were elected Ordinary Members of the Society.

Mr. D. C. GLEN, F.G.S., exhibited a number of fine Mineralogical specimens, chiefly from North America, including varieties of quartz, rock-crystals, and cairngorms.

Mr. JAMES ANDERSON read a series of notes on the Great Blue Lead and other "dead rivers" of California, with respect to their auriferous deposits, contributed by Mr. John S. Hitell and other American observers to the State Geological Survey. Mr. Anderson said he had brought forward these notes as bearing upon phenomena observed in our own country. Remarks were made by various members, Mr. William Jolly stating that the observations read afforded a beautiful corroboration of the phenomenon to be seen in the Scuir of Eig.

The adjourned discussion on Mr. D. Bell's paper "On some Boulders near Arden, Lochlomond," read at last meeting, followed, and was taken part in by Mr. William Jolly, F.G.S., Mr. John Young, F.G.S., and other members.

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SPECIAL MEETING IN THE LARGE HALL, 207 BATH STREET.

LECTURE BY SIR WILLIAM THOMSON, F.R.S., President of the Society.

16TH FEBRUARY, 1888.

Mr. WILLIAM JOLLY, F.G.S., in the Chair,

Who was accompanied to the platform by Sir William Thomson and Dr. John Murray of the *Challenger*.

The CHAIRMAN, in introducing the lecturer to the meeting, referred to his past services to the Geological Society of Glasgow, and hoped that many years would elapse before he was compelled by nature to give up his scientific researches. His scientific insight easily reached the tidemark of high genius, and he had, like all true men of genius, an innate modesty and simplicity of nature which were equally beautiful and equally rare. In these respects they all felt that he followed his great master, Newton, with whose spirit he was so deeply imbued, and in the light of whose researches he had done so much admirable work.

[For the lecture see page 322.]

The Chairman then introduced Dr. John Murray of the *Challenger*, who, in proposing a vote of thanks to the lecturer, said the addresses which Sir William Thomson had delivered to this Society had been of enormous service to scientific men, and the one they had heard would have as great an influence as those of the past. The great difficulty on a subject like this had always been—what would happen from certain suppositions? Sir William had given them a great deal of information in this respect. He had supposed certain cases, and shown that others would follow. Proceeding to speak of barriers, Mr. Murray remarked that it might not be generally known there was a barrier which ran from the North of Scotland towards Norway and Greenland. He himself had taken the soundings, and found it was only 200 fathoms underneath the surface of the sea at the present time. It had been ascertained that it was covered with glaciated stones. It was, as it were, a great *terminal morraine*. Regarding the Antarctic continent, he said, from the information they possessed, and looking to the beautiful experiments placed before the meeting, there was no reason to suppose that there was a vast accumulation of ice on that Antarctic continent. Indeed, they were quite sure it was a very ordinary continent.

SOCIETY'S ROOMS, 207 BATH STREET, 8TH MARCH, 1888.

Mr. DUGALD BELL, *Vice-President*, in the Chair.

Mr. James D. Graham, Ayr Grammar School, Ayr, was elected an Ordinary Member of the Society.

Mr. JOHN YOUNG, F.G.S., exhibited under the Society's microscope a transparent section from the bed of Intrusive Dolerite found in connection

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with the strata in which the fossil trees are imbedded at Victoria Park, Whiteinch. In one of the veins of the igneous rock recently exposed, and which passes through the roots of one of the trees, there are found the remains of a thin glassy surface on either face where cooling had taken place most rapidly. This glassy surface shows a spherulitic structure in which the spheres often have polygonal outlines through pressure contact while the rock was still fluid; and in these a fine radiated structure like that seen in some of the Arran Pitchstones has sometimes been developed, although the Whiteinch specimens only show the radiation in parts owing to the devitrification of the glassy structure which has afterwards taken place.

Mr. YOUNG also exhibited a specimen of Gold-bearing Quartz from a lode in the Mawddach Valley, near Dolgelly, North Wales, which had been presented to the Hunterian Museum, in 1885, by Mr. George Lamb, Glasgow. In his remarks Mr. Young referred to the geological position of the auriferous lodes of North Wales and to the average amount of gold per ton of lode stuff which they are expected to yield, probably not more than one ounce per ton.

Mr. JAMES THOMSON, F.G.S., exhibited several specimens of Gold-bearing Rocks from North America, on which he made some remarks.

Mr. JAMES STEEL read a paper by Mr. Thomas Scott, *Corresponding Member*, entitled, "Notes on a Shell-bearing Clay at Roxburgh Street, Greenock." [See page 267.] Mr. Scott's paper was illustrated by a map of the locality.

SOCIETY'S ROOMS, 207 BATH STREET, 12TH APRIL, 1888.

Mr. DANIEL M'MILLAN, *Vice-President*, in the Chair.

Dr. John Murray, F.R.S., of the *Challenger*, was elected an Honorary Member, and Dr. James Smith, LL.D., St. Peter's Lodge, Uddingston, was elected an Ordinary Member of the Society.

Mr. JOHN YOUNG, F.G.S., and Mr. D. C. GLEN, F.G.S., read a paper "On a section of Carboniferous Strata containing erect stems of Fossil Trees and beds of Intrusive Dolerite near Whiteinch." [See page 227.] After describing the beds with their fossil remains the authors spoke of the various considerations involved in their preservation, and concluded by expressing a strong hope that such an interesting epitome of geological history would be carefully protected for the benefit of students of geological phenomena and for the inhabitants generally.

The HON. SECRETARY then read a paper contributed by Mr. Robert Kidston, F.R.S.E., F.G.S., "Note on the Nature of the Fossil Trees found at Whiteinch." [See page 235.]

An interesting discussion followed and was taken part in by Messrs. William Jolly, F.G.S., James Thomson, F.G.S., James Anderson, and other members, also by Bailie Storrie and several of the Commissioners of the Burghs of Partick and Whiteinch.

A Committee was appointed to meet with and assist the authorities of

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the Victoria Park in the conservation of the Fossil Trees, consisting of Messrs. Glen, Young, Thomson, Jolly, Dairon, and the Hon. Secretary. It was agreed that 400 extra copies of Messrs. Young and Glen's paper should be thrown off for sale for the benefit of a fund for the purpose.

A number of photographic views and artists' sketches of the Fossil Trees were exhibited to the meeting.

SOCIETY'S ROOMS, 207 BATH STREET, 10TH MAY, 1888.

Mr. WILLIAM JOLLY, F.G.S., *Vice-President*, in the Chair.

Mr. Walter Dow, 2 May Terrace, Mount Florida, and Mr. J. M. Burnett, Duncairn Villa, Crosshill, were elected Ordinary Members of the Society.

Mr. JOHN YOUNG, F.G.S., said that since the date of last meeting several more stems of Fossil Trees, both upright and horizontal, had been laid bare at Victoria Park. As to statements which had been made in a Kilmarnock paper questioning the accuracy of his remarks last month on the spherulitic structure of the dolerite injected as thin veins through the Carboniferous strata at Whiteinch, he did not think it needful to take any formal notice of them as they were so utterly beside the mark.

Mr. YOUNG then exhibited under the Society's microscope a section of the coarse crystalline Intrusive Dolerite from the same place, which plainly showed it to be composed of a basic felspar crowded with slender crystals of apatite. There were also numerous crystalline mixtures of magnetic iron, titaniferous iron, and sulphide of iron, along with augite and olivine, the latter of a pale green colour with a radiated fan-like structure due probably to some subsequent alteration in its crystals.

Dr. R. H. TRAQUAIR, F.R.S., keeper of the Natural History Department of the Science and Art Museum, Edinburgh, read a paper "On the Selachian genus of Fossil Fish, *Cladodus* of Agassiz," with a description of a remarkable specimen from East Kilbride, in the collection of Mr. James Neilson, and which he proposed to name after that gentleman, *Cladodus Neilsoni*. The paper was illustrated by a series of graphic drawings of structure, sketched by the author on the blackboard, and remarks were made by Mr. John Young, F.G.S., James Thomson, F.G.S., and James Neilson.

Mr. WALTER BURNS read a paper entitled, "Notes on the Heads of Ayr," which was illustrated by a map of the coast section and by a number of specimens of rocks and fossils of the district. [See page 287.]

SOCIETY'S ROOMS, 207 BATH STREET, 31ST MAY, 1888.

Mr. DUGALD BELL, *Vice-President*, in the Chair.

The Very Reverend Canon M'Intosh, Airdrie, was elected an Ordinary Member of the Society.

Mr. ROBERT DUNLOP read a paper entitled, "A Note on a Peat Bed in

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Boulder-clay near Airdrie." [See page 312.] Remarks on the interesting nature of the occurrence were made by several members.

The HON. SECRETARY, on behalf of Mr. James Bennie, Geological Survey of Scotland, read a paper on "The Redemption of Sandstone Quarries." [See page 298.] An interesting discussion followed, and was taken part in by Messrs. John Young, F.G.S., James Thomson, F.G.S., and other members.

The CHAIRMAN then declared the session closed and hoped that all present would be spared to meet next October, in good health, and with good accounts to give of their summer rambles.

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Abstract of Treasurer's Accounts for the Year ending 30th September, 1886.

CASH ACCOUNT.

RECEIPTS.

Balance—Due by Treasurer at last Account,		£1	17 5
Annual Subscriptions—			
Subscriptions for current year, 150 at 10s.,	£75 0 0		
New Members, 11 at 10s.,	5 10 0		
		80	10 0
Interest on Invested Funds,		9	14 5
Publications Sold,		1	18 2
Bank Account—Drawn,		40	0 0
Balance due to Treasurer,		0	1 5
		£134	1 5

EXPENDITURE.

Transactions—			
Robert MacLehose, for Printing, etc.,		£73	7 0
Ordinary Expenditure—			
Rent, Insurance, and Attendance,	£12 11 6		
Collector's Commission,	3 14 0		
Stationery, Postages, and Petty Disbursements,	2 10 6		
Printing Cards, Circulars, Special Papers, and Receipt Book,	18 19 6		
Engraving,	0 18 1		
Disbursements by Secretaries,	6 3 4		
Disbursements by Librarian,	5 17 0		
Subscription to Palæontographical Society,	1 1 0		
Expenses at Professor Heddle's Lectures,	0 10 6		
		52	5 5
Library—			
New Books,	£4 16 0		
Assistance in Compiling Catalogue,	3 3 0		
List of Foreign Books for Catalogue,	0 10 0		
		8	9 0
		£134	1 5

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ABSTRACT OF TREASURER'S ACCOUNTS.—*Continued.*

STOCK ACCOUNT.

To Account for Binding,			£21	17	5
,, ,, New Books,			7	9	4
,, ,, Circulars, Cards, and Catalogue,			17	8	6
			£46	15	3
,, Balance to Credit,			465	4	9
			£512	0	0

By Funds Invested—			
Loan to Corporation of Campbeltown,	£250	0	0
,, Books in Library,	160	0	0
,, *Transactions* in Stock,	60	0	0
,, Furniture,	22	0	0
,, Fossils (not valued),	0	0	0
,, Microscope and Accessories,	20	0	0
	£512	0	0

LIFE SUBSCRIPTION ACCOUNT.

1886—Sept. 30.—To Balance at Credit,	£120	15	0

1885—October 1.—By Balance,	£120	15	0

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Abstract of Treasurer's Accounts for the Year ending 30th September, 1887.

CASH ACCOUNT.

RECEIPTS.

Annual Subscriptions—			
For current year, 145 at 10s.,	£72	10	0
New Members, 13 at 10s.,	6	10	0
Arrears for 1885-6, 3 at 10s.,	1	10	0
	£80	10	0
Life Subscription—Mr. John Fowler,	5	5	0
Interest on Invested Funds,	9	4	6
Repayment in Part of Loan of £250 by Corporation of Campbeltown,	80	0	0
Publications Sold,	2	5	7½
	£177	5	1½

EXPENDITURE.

Balance—Due to Treasurer at close of last Account,				£0	1	5
Transactions—						
Printing and Binding Part I., Vol. 8,	£68	18	9			
Engraving Plates,	4	18	0			
Printing Authors' Copies,	7	17	0			
				81	13	9
Catalogue—Paid to Account,				16	10	6
Ordinary Expenditure—						
Rent, Insurance, and Attendance,	£12	11	6			
Collector's Commission,	3	13	6			
Stationery, Postages, and Petty Disbursements,	0	19	3			
Printing Cards, Circulars, etc.,	11	8	0			
Disbursements by Secretaries,	4	16	6			
Disbursements by Librarian,	4	15	10½			
Subscription to Palæontographical Society,	1	1	0			
Fitting up Bookcases,	2	9	0			
				41	14	7½
Library—						
New Books,	£7	16	10			
Bookbinding,	25	8	0			
				33	4	10
Balance in Treasurer's hands,				4	0	0
				£177	5	1½

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ABSTRACT OF TREASURER'S ACCOUNTS.—*Continued.*

STOCK ACCOUNT.

To Balance of Account for Catalogue,	£6	17	0	By Funds Invested—	
,, Do., for Cards,	1	8	0	Loan to Corporation of Campbeltown,	£170 0 0
,, Balance to Credit,	418	15	0	,, Books in Library,	160 0 0
				,, *Transactions* in Stock,	55 0 0
				,, Furniture,	22 0 0
				,, Fossils (not valued),	0 0 0
				,, Microscope,	20 0 0
	£427	0	0		£427 0 0

LIFE SUBSCRIPTION ACCOUNT.

1887—Sept. 30.—To Balance,	£126	0	0	1886—Oct. 1.—By Balance,	£120 15 0
				1887—Jan. 25.— ,, John Fowler,	5 5 0
	£126	0	0		£126 0 0

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OFFICE-BEARERS FOR SESSION 1888-89.

President—SIR WILLIAM THOMSON, LL.D., F.R.S., &c.

Vice-Presidents.

For Three Years.	*For Two Years.*	*For One Year.*
JOSEPH SOMMERVILLE.	DUGALD BELL.	DANIEL M'MILLAN.

COUNCIL.

WM. ARMOUR, C.E.	D. C. GLEN, F.G.S.	J. YOUNG, F.G.S.
WM. JOLLY, F.G.S.	WALTER BURNS.	JOHN DOUGAN.
ROBT. I. STEELE.	J. DAIRON, F.G.S.	ROBERT DUNLOP.
JAS. S. M'LENNAN.	J. THOMSON, F.G.S.	JOHN HOWAT.

Hon. Treasurer—JOHN WIGHT, C.A., 150 Hope Street.

Hon. Librarian—JAMES WHITE, 56 Rose Street, Garnethill.

Hon. Secretary and Editor of *Transactions*—JAMES B. MURDOCH, F.R.Ph.S.E., Capelrig, Mearns, Renfrewshire.

Assistant Hon. Secretary—GAVIN M. PRATT, 104 West Graham Street.

Publishing Committee.

JOHN YOUNG.	WILLIAM JOLLY.	GAVIN M. PRATT.
D. C. GLEN.	DUGALD BELL.	J. B. MURDOCH, *Convener.*

Library and Museum Committee.

WM. ARMOUR.	D. M'LENNAN.	R. I. STEELE.
J. SOMMERVILLE.	JOHN HOWAT.	JAS. WHITE, *Convener.*

Finance Committee.

JOHN DOUGAN.	R. I. STEELE.
D. M'MILLAN.	JOHN WIGHT, *Convener.*
DUGALD BELL.	

Auditors.

ROBERT GILL. | DAVID PEARSON.

LIST OF MEMBERS at 1st December, 1888.

Honorary Members.

Year of Election.

1865. Geikie, Archibald, LL.D., F.R.S., F.G.S., Director-General of the Geological Survey of Great Britain and Ireland, Museum, Jermyn Street, London.

1867. Jones, T. Rupert, F.R.S., F.G.S., 10 Ulverdale Road, King's Road, Chelsea, London, S.W.

1867. Kirkby, James W., Ashgrove, Windygates, Leven, Fifeshire.

1867. Woodward, Henry, LL.D., F.G.S., British Museum, Natural History Department, South Kensington, London.

1867. M'Chesney, Joseph H., Professor of Geology, University of Chicago, U.S.

1871. Hull, Edward, F.G.S., &c., Director of the Geological Survey of Ireland, 14 Hume Street, Dublin.

1872. Thomson, Sir William, LL.D., F.R.S., Professor of Natural Philosophy, University of Glasgow, *President.*

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Year of Election.

1872. Young, John, M.D., F.G.S., Professor of Natural History, University of Glasgow.
1879. Hunter, John R. S., LL.D., Daleville, Braidwood, Carluke. [1864]*
1883. Judd, J. W, F.R.S., F.G.S., Science Schools, South Kensington, London, S.W.
1883. Brown, Robert, M.D., F.G.S., &c., Ferslev, Rydal Road, Streatham, London, S.W.
1885. Heddle, M. F., M.D., F.R.S.E., late Professor of Chemistry and Mineralogy, St. Andrews.
1888. Murray, John, LL.D., F.R.S.E., of the "Challenger," Edinburgh.

Honorary Associates.

1867. Struthers, Thomas, Gourock. [1859]
1867. Croll, James, LL.D., Edinburgh.
1871. Crosskey, Rev. Henry W., LL.D., F.G.S., 17 Gough Road, Edgbaston, Birmingham. [1858]
1871. Horne, James, London. [1858]
1871. Farie, James, Canonbury, London. [1859]
1878. Lapworth, Charles, LL.D., F.G.S., Professor of Geology, Sir Josiah Mason College of Science, Birmingham.
1881. Wünsch, E. A., F.G.S., Carharrack, Scarrier, Cornwall. [1858]
1883. Traquair, R. H., M.D., F.R.S.E., F.G.S., Museum of Science and Art, Edinburgh.
1883. Geikie, James, LL.D., F.R.S.E., F.G.S., Professor of Geology and Mineralogy, University of Edinburgh. [1873]
1886. Robertson, David, F.L.S., F.G.S., Fern Bank, Millport. [1867]

Corresponding Members.

1859. Dougall, John, M.D., 115 Paisley Road, Glasgow.
1860. Sommerville, George, Thornliebank.
1862. Hunter, James, Ironmaster, Coltness.
1864. Grierson, T. B., M.D., Thornhill, Dumfriesshire.
1864. Mitchell, Rev. Hugh, LL.D., Craig, Montrose.
1865. Winchell, Alex., Professor of Geology, University of Michigan, U.S.
1866. Gloag, Rev. Dr. Paton J., Manse, Galashiels.
1866. Myers, Rev. Edward, F.G.S., 20 Summerhill Terrace, Birmingham.
1867. Craig, Robert, Langside, Beith.
1867. Gordon, Rev. Dr., Manse of Birnie, Elgin.
1867. Kerr, David, Wemyss Colliery, Fifeshire.
1871. Jack, R. L., F.G.S., Government Geologist, Townsville, Queensland.
1871. Jamieson, T. F., F.G.S., Ellon, Aberdeenshire.
1871. Kinahan, G. H., Geological Survey of Ireland, Dublin.
1871. Molyneux, William, F.G.S., Burton-on-Trent.
1871. Ward, John, F.G.S., 23 Stafford Street, Longtown, Staffordshire.
1878. Stewart, Rev. Alex., LL.D., F.S.A.Scot., Ballachulish Manse, Nether-Lochaber.

* The date *after* a name is that of election as an ordinary member.

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Year of Election.

1883. Lindström, Professor G., State Museum, Stockholm, Sweden.
1883. Scott, Thomas, 14 Lorne Street, Leith Walk, Edinburgh. [1880]
1883. Smith, W. Anderson, Ledaig.
1884. Dobbie, J. J., M.A., D.Sc., Professor of Chemistry and Geology, University College, Bangor, North Wales. [1876]
1884. Nathorst, Dr. Alfred Gabriel, Geological Survey Office, Stockholm, Sweden.
1887. Naismith, Thomas, 6 Broompark Terrace, Dennistoun. [1861]

Resident Members.

1868. Allan, Archibald B., C.E., 4 Victoria Drive, Mount Florida.
1882. Anderson, James, 76 Howard Street, Glasgow.
1881. Armour, P. W., Jane Villa, Pollokshields.
1881. Armour, Wm., C.E., 207 West George Street, Glasgow.

1875.*Bain, Sir James, 3 Park Terrace, Glasgow.
1867. Bannerman, David, 9 Waterloo Street, Glasgow.
1858.*Barr, Thomas M., C.E., Caledonian Railway, Perth. [1881] †
1874.*Belch, John, 142 Main Street, Anderston, Glasgow.
1858. Bell, Dugald, 27 Lansdowne Crescent, Glasgow, *Vice-President.*
1859. Bennie, James, Geological Survey of Scotland, Edinburgh.
1877. Blair, Matthew, F.G.S., 104 Causeyside, Paisley.
1884. Bone, Charles C., C.E., 23 Miller Street, Glasgow.
1887. Boyd, John, 9 Prince's Square, Regent Park, Glasgow.
1882. Brand, John, 81 Gloucester Street, Glasgow.
1887. Brown, Andrew, 27 Roselea Drive, Dennistoun.
1883. Brown, George S., B.Sc., 22 Carnarvon Street, Glasgow.
1887. Bryden, J. F., 25 Shamrock Street, Glasgow.
1887. Bryson, Alexander, 142 Trongate, Glasgow.
1877. Buchanan, John, 230 Duke Street, Glasgow.
1888. Burnet, J. M., Duncairn Villa, Crosshill.
1866. Burnet, John, 167 St. Vincent Street, Glasgow.
1886. Burns, John A., 42 Virginia Street, Glasgow.
1876. Burns, Walter, 42 Virginia Street, Glasgow.

1873. Cameron, Robert, 31 Westbourne Gardens, Kelvinside.
1877. Campbell, John MacNaught, Kelvingrove Museum, Glasgow.
1885. Campbell, Wm., Seafield Cottages, Claythorn, Partick.
1880. Carmichael, Robert S., Audit Office, St. Enoch Station, Glasgow.
1865. Carrick, John, 74 Hutcheson Street, Glasgow.
1885. Clark, John, 171 Watson Street, Motherwell.
1888. Clark, Ex-Provost, Paisley.
1875.*Clavering, Thomas, 30 Gordon Street, Glasgow.
1883. Clelland, John, B.Sc., C.E., Woodhead Cottage, Old Monkland.
1875.*Collins, Sir William, 3 Park Terrace, East, Glasgow.

† Life Members are indicated by a [*]. When a date is placed *after* the name of a Resident Member, it is that of election as a Life Member.

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1866. Connal, Sir Michael, Virginia Buildings, Glasgow.
1874. Cox, C. C., Castle Street, Barnstaple.
1886. Crockett, John D., Curran House, Dungannon, County Tyrone.
1888. Cullen, William, 4 Catherine Street, N.

1861.*Dairon, James, F.G.S., 4 Garden Street, Glasgow. [1874]
1877.*Dansken, John, 121 West Regent Street, Glasgow.
1874. Darling, George E., 178 St. Vincent Street, Glasgow.
1884. Davidson, Thomas, 92 Maxwell Street, Glasgow.
1881. Dickson, John, 196 Parliamentary Road, Glasgow.
1876. Dixon, E. M., 11 Hopetoun Place, Glasgow.
1883.*Dobbie, Charles Lizars, 21 Hamilton Park Terrace, Glasgow.
1886. Dobbie, Rev. R. W., 1 Craigpark Terrace, Dennistoun.
1881.*Dougan, John, 1 Wilson Street, Hillhead, Glasgow.
1888. Dow, Walter, 2 May Terrace, Mount Florida.
1887. Dow, Wm., 165 Hospital Street, Glasgow.
1867. Drew, Alexander, 175 West George Street, Glasgow.
1875. Dunlop, E. D., 40 West Nile Street, Glasgow.
1883. Dunlop, Robert, Whiterigg, Airdrie.
1868. Dunn, William, 183 West George Street, Glasgow.

1884. Edmiston, James, 297 Argyle Street, Glasgow.

1872.*Farquhar, Ex-Bailie John, 13 Belhaven Terrace, Hillhead, Glasgow.
1872. Forsyth, David, M.A., B.Sc., 49 Carnarvon Street, Glasgow.
1885. Fullarton, J. H., M.A., B.Sc., Natural History Rooms, University of Glasgow.

1866. Gale, James M., C.E., Corporation Water Works, Glasgow.
1884. Gill, Robert, 109 West George Street, Glasgow.
1887. Gardner, John, 21 Clyde Place, Glasgow.
1873.*Gilmour, Thomas, M.D., Cecil Place, Paisley Road, Glasgow. [1878]
1866.*Glen, David Corse, C.E., F.G.S., 14 Aunfield Place, Glasgow. [1881]
1879. Graham, Alex. M., 20 Dixon Street, Glasgow.
1888. Graham, James D., M.A., Ayr Grammar School, Ayr.
1877. Graham, M. M., 21 Bath Street, Glasgow.
1866. Grant, James, 8 Queen's Terrace, Glasgow.
1881. Gray, Harry, 15 Newton Terrace, Glasgow.
1886. Guy, Robert, The Wern, Pollokshaws.

1872. Hamilton, Archibald, C.E., Clyde Navigation Office, Robertson Street, Glasgow.
1880. Harvie, John, Clydesdale Bank, Glasgow.
1885. Henderson, George G., M.A., Chemical Laboratory, University of Glasgow.
1880. Henderson, James, M.A., 3 Armadale Street, Dennistoun.
1876. Henderson, John, 1 Livingstone Terrace, Paisley Road, Glasgow.

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1886. Hewett, H. S., 8 Milton Terrace, Langside.
1877. Hill, Thomas N., 209 St. Vincent Street, Glasgow.
1877. Hislop, George R., F.C.S., F.R.S.S.E., Corporation Gas Works Paisley.
1870. Horne, R. R., Mount Vernon Colliery, Tollcross.
1884. Howat, John, 527 New City Road, Glasgow.
1886. Hugh, James, Nelson Cottage, Langside.
1866. Hunt, Edmund, C.E., 87 St. Vincent Street, Glasgow.
1867. Hunter, Matthew, 70 Union Street, Glasgow.

1884. Jolly, William, F.R.S.E., F.G.S., 25 St. Andrew's Drive, Pollokshields.

1870. Ker, William, 1 High Windsor Terrace, Glasgow.
1877. Kerr, Charles James, Greenfaulds House, Cumbernauld.
1877. Kincaid, Thomas, 9 Lansdowne Crescent, Glasgow.
1882. King, Hugh B., Kilwinning, Ayrshire.
1882. King, Robert C., C.A., Kilwinning, Ayrshire.
1874. King, Thomas, 110 Hill Street, Garnethill, Glasgow.
1860. Kirsop, John, 98 Argyle Street, Glasgow.
1867. Knox, Adam, 10 Clayton Terrace, Dennistoun.
1872. Knox, John, 41 Mid Wharf, Port-Dundas, Glasgow.

1883. Laird, Andrew, C.E., 123 St. Vincent Street, Glasgow.
1874. *Lamb, Thomas, 190 Parliamentary Road, Glasgow.
1873. Long, John Jex, 11 Doune Terrace, Kelvinside, Glasgow.
1880. Lucas, William, 133 West George Street, Glasgow.

1873. Macbeth, Daniel, Ashburn, Ascog, Rothesay.
1866. M'Clelland, Andrew S., C.A., 115 St. Vincent Street, Glasgow.
1884. M'Donald, A. B., C.E., 74 Hutcheson Street, Glasgow.
1867. M'Glashan, John, 114 Candleriggs, Glasgow.
1882. Mackintosh, Rev. John, The Manse, Uddingston.
1888. M'Intosh, Very Rev. Canon, Airdrie.
1883. MacIntyre, A. C., 99 Renfield Street, Glasgow.
1888. Macintyre, Duncan, North Public School, Alexandria.
1886. M'Laren, Robert, Daisybank, Crofthill Avenue, Uddingston.
1881. *Maclay, David J., 3 Woodlands Terrace, Glasgow.
1877. M'Lay, William, 11 May Terrace, Mount Florida.
1882. M'Lennan, James S., Oswald Public School, Knightswood, Maryhill.
1878. M'Millan, Daniel, 26 Ashton Terrace, Hillhead, *Vice-President*.
1876. M'Nee, Forrest, 5 Cambridge Terrace, Herriot Street, Pollokshields.
1883. M'Whirr, John, 9 Kilmailing Terrace, Cathcart.
1887. Main, John, F.G.S., 3 Beaconsfield Street, Partick.
1886. Manford, John, Wellfield, Partickhill.
1874. Marshall, Robert, 97 Wellington Street, Glasgow.
1871. Mason, Robert, F.L.S., 6 Albion Crescent, Dowanhill, Glasgow.

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1887. Meiklejohn, Andrew, 52 Cromwell Street, Glasgow.
1876. Millar, Archd., Shawlands Academy, Crossmyloof.
1867. Millar, John (J. Black, Drew, & Co.), 23 Royal Exchange Square, Glasgow.
1887. Millar, W. J., C.E., 261 West George Street, Glasgow.
1887. Miller, James, 1 Athole Terrace, Hillhead.
1881. Mitchell, G. A., 67 West Nile Street, Glasgow.
1887. Mitchell, Robert, 24 Howard Street, Bridgeton.
1885. More, Robert, 505 Sauchiehall Street, Glasgow.
1877. Moore, Robert T., C.E., B.Sc., 160 Hope Street, Glasgow.
1865. Mossman, John, 6 Queen's Terrace, West, Glasgow.
1877.*Muirhead, Henry, M.D., Bushy Hill, Cambuslang.
1859. Murdoch, James B., F.R.Ph.S.E., Capelrig, Mearns, *Honorary Secretary.*
1875. Murdoch, William, 20 Carlton Place, Glasgow.
1870.*Murray, David, LL.D., 13 Fitzroy Place, Glasgow.

1865. Napier, J. W., Woodielea, 14 Windsor Circus, Glasgow.
1868. Neilson, Richard, 110 John Street, Glasgow.
1867. Norman, John, Keppochhill Engine Works, Glasgow.

1869. Orr, John, 12 Newhall Terrace, Glasgow.

1875. Pearson, D., 15 Carnarvon Street, Glasgow.
1877. Pratt, Gavin M., 104 West Graham Street, Glasgow, *Assistant Hon. Secretary.*

1873. Rankine, David, C.E., 75 West Nile Street, Glasgow.
1880. Reid, James A. (of M'Grigor, Donald, & Co.), 172 St. Vincent Street, Glasgow.
1881. Reid, John, 112 Bath Street, Glasgow.
1866. Reid, James G., 9 St. Vincent Place, Glasgow.
1874. Renwick, John, Blacklands, Maryhill.
1877. Rhind, John, 82 Hill Street, Garnethill, Glasgow.
1887. Richmond, Thomas, L.R.C.P.E., 26 Burnbank Terrace, Glasgow.
1867. Robertson, Archibald, 25 Queen Street, Glasgow.
1872. Robertson, David, 205 Hope Street, Glasgow.
1866. Robertson, John, 10 Valeview Terrace, Mount Florida.
1868. Robertson, Joseph, 110 John Street, Glasgow.
1878. Ross, David, M.A., B.Sc., LL.D., 47 Carnarvon Street, Glasgow.
1875.*Rottenburg, Paul, Holmhurst, Dowanhill Gardens, Glasgow.
1865. Rowan, David, 22 Woodside Place, Glasgow.

1888. Sinclair, Thomas, 206 New Dalmarnock Road, Glasgow.
1887. Sinclair, William, Grange, Bothwell.
1871.*Smellie, Thos. D., 213 St. Vincent Street, Glasgow.
1888. Smith, James, LL.D., St. Peter's Lodge, Uddingston.
1865. Smith, John, Eglinton Ironworks, Kilwinning.

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1887. Somerville, Rev. James E., B.D., 11 Southpark Terrace, Hillhead.
1871. Sommerville, Joseph, 76 Henderson Street, Glasgow, *Vice-President.*
1881. Steel, James, 5 Rosehall Street, Glasgow.
1884. Steele, Robert Innes, 28 Leven Street, Pollokshields.
1886. Steuart, Walter, 12 Pollok Road, Pollokshaws.
1880. Stewart, James, of Williamwood, Cathcart.
1878. Stewart, James F., Kippen, Stirling.
1878. Stewart, Thomas, Hydraulic Engineers' Department, Cape Town.

1858. Thomson, James, F.G.S., 3 Abbotsford Place, Glasgow.
1878. Thomson, John, Govan Park, Govan.
1885. Tullis, David, Glencairn, Burnside, Rutherglen.
1885. Tullis, James T., The Anchorage, Burnside, Rutherglen.
1886. Tulloch, Rev. W. W., B.D., 3 Leslie Drive, Pollokshields.

1874. White, James, 56 Rose Street, Garnethill, Glasgow, *Hon. Librarian.*
1874. White, James, Free Normal School, Glasgow.
1864. Whitelaw, Alexander, 87 Sydney Street, Glasgow.
1880. Whitelaw, Thomas, Coalmaster, Motherwell.
1874. Whyte, John, 150 Holland Street, Glasgow.
1866. Wight, John, C.A., 150 Hope Street, Glasgow, *Hon. Treasurer.*
1879. Wight, Robert John, C.E., 7 Berlin Place, Pollokshields.
1881. Wilson, George, 119 Montrose Street, Glasgow.
1874. Wilson, John, 4 Washington Street, Glasgow.
1881. Wotherspoon, David, 130 Dumbarton Road, Glasgow.

1859.*Young, John, F.G.S., Hunterian Museum, University of Glasgow. [1869]
1875.*Yuille, Wm. Smith, 119 Trongate, Glasgow.

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LIST OF SOCIETIES AND INSTITUTIONS

WITH WHICH

EXCHANGES ARE MADE.

GREAT BRITAIN AND IRELAND.

ENGLAND.—Birmingham Philosophical Society.
,, Bristol Naturalists' Society.
,, Cornwall—Royal Institute of Cornwall.
,, Essex Field Club.
,, Gloucester Naturalists' Club.
,, Hertfordshire Natural History Society and Field Club.
,, Leeds Geological Association.
,, Liverpool—Geological Society.
,, Literary and Philosophical Society.
,, London—British Association for the Advancement of Science.
,, British Museum—Nat. Hist. Department.
,, Geologists' Association.
,, Geological Society of London.
,, Patent Office Library.
,, Manchester—Geological Society.
,, Literary and Philosophical Society.
,, Newcastle Natural History Society.
,, Norwich Geological Society.
,, Warwickshire Field Club.
IRELAND.—Dublin—Royal Geological Society.
,, Belfast Naturalists' Field Club.
SCOTLAND.—Berwickshire Naturalists' Club.
,, Dumfries and Galloway Natural History and Antiquarian Society.
,, Edinburgh—Geological Society.
,, Geological Survey of Scotland.
,, Royal Physical Society of Edinburgh.
,, Royal Scottish Geographical Society.
,, Royal Society of Edinburgh.
,, Glasgow—Athenæum.
,, College of Science and Art.
,, Mechanics' Library, Anderson's College.
,, Mitchell Free Library.
,, Natural History Society of Glasgow.
,, Philosophical Society.
,, Stirling's Library.
,, Inverness Field Club and Scientific Society.
,, Paisley Free Library.
,, Perthshire Society of Natural Science.
,, Stirling Natural History and Archæological Society.

BRITISH COLONIES.

AUSTRALIA.—Queensland—Geological Survey.
,, Sydney—Department of Mines.
,, Royal Society of New South Wales.
,, Melbourne—Department of Mines.
,, Public Library.
,, Geological Society of Australasia.

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CANADA.—Halifax—Nova Scotia Institute of Natural Sciences.
,, Hamilton Association.
,, Montreal—Geological and Natural History Survey of Canada.
Natural History Society.
,, Ottawa—Geological and Natural History Survey.
,, Toronto—Canadian Institute.
INDIA.—Calcutta—Geological Survey of India.

FOREIGN COUNTRIES.

AUSTRIA.—Prague—Naturw. Landesdurchforschung von Böhmen.
,, Naturhistorischen Verein, "Lotos."
,, Trieste—Societa Adriatica di Scienze Naturali.
,, Vienna—K.K. Geologischen Reichsanstalt.
,, Kaiserlichen Academie der Wissenschaften.
,, K.K. Geologischen Botanischen Gessellschaft.
BELGIUM.—Brussels—Academia Royale de Belgique.
,, Societe Royale des Sciences de Liege.
FRANCE.—Caen—Société Linneenne de Normandie.
,, Paris—Société Geologique de France.
GERMANY.—Berlin—Deutschen Geologischen Gesellschaft.
,, Gesammten Naturwissenschaften.
,, Zeitschrift für Naturwissenschaften.
,, Bonn—Verhandlungen des Naturhistorischen Vereines.
,, Dresden—Naturwissenschaftlichen Gesellschaft, "Isis."
,, Munich—Konigl. Bayer. Akademie der Wissenschaften
ITALY.—Milan—Societa Italiana di Scienze Naturali.
,, Modena—Regia Accademia di Scienze, Lettere, ed Arti.
,, Pisa—Societa Toscana di Scienze Naturali.
,, Rome—Reale Accademia dei Lincei.
,, Venice—Reale Istituto Veneto de Scienze.
NORWAY.—Christiania—University Library.
PORTUGAL.—Lisbon—Commissão dos Trabalhos Geologicos.
RUSSIA.—Moscow—Societé Imperiale des Naturalistes.
,, St. Petersburg—Institut des Mines, Comité Geologique.
,, Musée Geologique, Université Imperiale.
SWEDEN.—Stockholm—Svenska Academien.
UNITED STATES.—Boston—Natural History Society of Boston.
,, Colorado—Denver Scientific Society.
,, Minnesota—Geological and Natural History Survey.
,, Mineapolis Academy of Natural Sciences.
,, New Concord—Elisha Mitchell Scientific Society.
, New Haven, Conn.—Academy of Arts and Sciences.
,, New York—Academy of Sciences.
,, Philadelphia—Academy of Natural Sciences.
,, American Philosophical Society.
,, St. Louis, Missouri—Academy of Sciences.
, Washington—Geological Survey.
,, Smithsonian Institution.
,, Wisconsin—State Geological Survey.

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PUBLICATIONS

OF THE

GEOLOGICAL SOCIETY OF GLASGOW.

TRANSACTIONS.

		Prices to Members.
Vol. I.,	Part 1.—On the Geology of the Campsie District. By John Young, F.G.S. Second Edition. 8vo.,	1/6
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